Report No. CG-D-13-96

Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU) Phase 3

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FINAL REPORT
February 1996

Prepared for:

U.S. Department of Transportation
United States Coast Guard
Office of Research and Development
Washington, DC 20593-0001

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CG-D-13-96		

4. Title and Subtitle	5. Report Date
Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU), Phase 3	February 1996
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Bert Macesker, John Hannon, Eric Bernholz	R&DC 07/96

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
U.S. Coast Guard Research and Development Center 1082 Shennecossett Road Groton, Connecticut 06340-6096	11. Contract or Grant No.
	13. Type of Report and Period Covered Final Report
12. Sponsoring Agency Name and Address Department of Transportation U.S. Coast Guard Office of Research and Development Washington, D.C. 20593-0001	14. Sponsoring Agency Code Commandant (G-MCO) USCG Headquarters Washington, D.C. 20593-0001

15. Supplementary Notes: The R&DC technical point of contact is Bert Macesker, 860-441-2726.

16. Abstract

This report presents the results of the third and final phase of an R&D project that investigated the use of portable computers as a means to streamline data capture by Coast Guard inspectors in the field.

A technology demonstration took place at the Coast Guard Marine Inspection Office (MIO) New York. This demonstration incorporated software and hardware refinements based on Phase 2 marine inspector feedback.

A number of significant new features were added to the MPIU system including a linked on-line reference library with commonly used rules and regulations, Marine Inspection Pre-Inspection Package (MIPIP) to MPIU interface, simple deficiency database, MPIU to MPIU communications interface, color digital cameras, and field printable certificates.

Phase 3 goals included the evaluation of the potential of voice recognition technology, updating a functional description of a MPIU system, evaluating the prospects of interoperability with classification societies, and performance of a cost/benefit study associated with a Coast Guard MPIU capability.

17. Key Words	18. Distribution Statement
marine inspector portable computers tankships marine safety	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. SECURITY CLASSIF. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

METRIC CONVERSION FACTORS

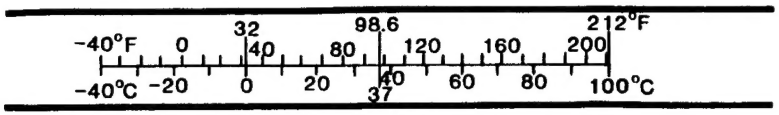
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	* 2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



EXECUTIVE SUMMARY

This report represents the results of the third and final phase to an R&D project that investigated the prospects for streamlining data capture in the field by Coast Guard marine inspectors with portable computers. Phase 1 consisted of extensive field surveys to determine the needs of Coast Guard marine inspectors for improved management of inspection data, a rough specification of performance requirements based on these surveys, and identification of non-developmental hardware and software available at that time. Phase 2 involved the development of a working prototype Marine Portable Inspection Unit (MPIU) that could be used to evaluate issues surrounding the use of a computerized inspection capability for Coast Guard marine inspectors. The prototype MPIU, built around a pen-based portable computer, was fielded in a short technology demonstration in Marine Safety Office (MSO) New Orleans. Phase 3 involved a second iteration of a technology demonstration at a different inspection office with software and hardware refinements based on Phase 2 marine inspector feedback. In Phase 3 a number of significant new features were added to the MPIU system including a linked on-line reference library with commonly used rules and regulations, Marine Inspection Pre-Inspection Package (MIPIP) to MPIU interface, simple deficiency database, MPIU to MPIU interface, color digital cameras, and field printable certificates. The technology demonstration took place at Marine Inspection Office (MIO) New York, with specific goals of evaluating the new MPIU features, the potential of voice recognition technology (Appendix A), updating a functional description of an MPIU system (Appendix B), prospects for interoperability with classification societies, and cost/benefit study associated with a Coast Guard MPIU capability. The cost/benefit study will be published as a separate report.

The observations of the test group at MIO New York mirrored the observations of the MSO New Orleans marine inspectors in Phase 2. This was significant in that it validated the R&D study findings as being representative of marine inspectors in general as opposed to a specific group. The most significant concern with regards to the execution of both Phase 2 and 3 study was the lack of an interface between the MPIU and Marine Safety Information System (MSIS) which ultimately limited the usefulness of the MPIU to that of a sophisticated 840 book with on-line reference capabilities. The potential of a fully capable MPIU tool was easily recognized by all of the marine inspector participants in these technology demonstrations (as being substantial).

Generally, the MPIU hardware should consist of notebooks with portable printers that can be set up in temporary offices or spaces on a vessel. Inspectors want the option of a portable pen-based computer to take with them on some inspections where both platforms have sufficient reference libraries of governing U.S. and international rules and regulations that eliminate the need to carry any paper references.

Implementation of a fully functional MPIU system will not change the Coast Guard business of marine inspection but would make Coast Guard inspection functions more efficient for both the marine inspectors and boat owners waiting for inspection results. The MPIU system will eliminate needless steps in transcription, copying, and re-typing of inspection information between the inspection site and office.

Some technical hurdles, e.g., deck-to-tank space communications in a shipyard environment and/or reduced hardware size for body worn systems, must be overcome before computer voice recognition technology can be beneficial to capturing inspection data in the field.

With the advent of the new Coast Guard standard workstations (CGSWIIIs), there will be operation system compatibility with classification society computers, but a common format for collecting specific data at the field level may not be realistic in the near future. The Coast Guard should not promulgate standards on how marine inspection data is electronically captured or formatted since there is limited information that is likely to be shared between the Coast Guard and classification societies.

A prototype two-way interface should be developed between the MPIU and MSIS followed by a pilot study at MIO New York. Even though MSIS will be replaced in a couple of years by a new Marine Safety Network (MSN), having a prototype interface now would permit the study of time, resources, and new streamlined office procedures involved in the exchange of inspection data between portable MPIUs and MSN as it would relate to Coast Guard wide implementation. Another cost/benefit study should be conducted in parallel with the pilot study, the results of which will reflect more realistic costs, than the limited R&D cost/benefit study. The pilot study should be jointly managed by G-MIR as the technical manager and G-MCO as the program sponsor. Coast Guard R&D Center involvement would transition with support in the development of the MPIU-MSIS interface.

ACKNOWLEDGMENTS

The U.S. Coast Guard gratefully acknowledges the cooperation of the many organizations and companies in performing the efforts discussed in this report. Table 1 in this report provides an overview of research participants. The R&D Center expresses its appreciation to Coast Guard marine inspectors who have enthusiastically contributed their feedback and ideas for developing a field portable inspection capability. The technical support from Mr. Desruisseau of the R&D Center Marine Engineering Branch is also acknowledged and appreciation is expressed to Dr. Allen of the R&D Center Marine Engineering Branch for his support in his capacity as the Marine Safety Project Manager.

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1 Background

1.1 The U.S. Coast Guard's Inspection Responsibilities

The Coast Guard is required by Title 46, U.S. Code (USC), to periodically inspect certain vessels registered in the United States or operating in U.S. waters to verify seaworthiness, structural integrity, and passenger and crew safety. Inspections also verify conformance with the pollution laws of Title 33, USC. Virtually all cargo-carrying and passenger vessels which use U.S. ports are subject to Coast Guard inspection. A large number of previously uninspected U.S. registered commercial fishing vessels have recently become subject to inspection under the Commercial Fishing Industry Vessel Safety Act of 1988 and the regulations resulting from that legislation.

The Coast Guard maintains a corps of professional inspectors to carry out its inspection responsibilities. Most inspectors are uniformed Coast Guard officers or warrant officers, although many inspection departments have a few civilian inspectors. Most of these inspectors are based at regional Coast Guard Marine Inspection Offices (MIOs) or at the inspection departments of regional Coast Guard Marine Safety Offices (MSOs) under the direction of the local Officers in Charge of Marine Inspection (OCMIs) and Chiefs of Inspection Departments (CIDs). A small group of highly experienced senior inspectors (the traveling inspection staff) operates out of CG Headquarters, functioning mainly in an advisory and troubleshooting capacity.

U.S. flag vessels are required to have a current Coast Guard Certificate of Inspection (COI) in order to operate legally in U.S. waters or elsewhere. This certificate is issued after an extensive initial inspection conducted during construction or upon entry of the vessel into U.S. registry and is good for a period of two years. Periodic reinspections (generally every year) are required to maintain the COI. For each reinspection, CG inspectors are required to conduct a close-up visual inspection of the exterior and all interior spaces of U.S. flag vessels.

Foreign-flag vessels operating in U.S. waters are required to have current Certificates of Compliance issued by the Coast Guard and must satisfy the requirements of the United Nations Safety of Life at Sea conventions of 1974 and 1983 (SOLAS 74/83), the 1966 Load Line Convention, the 1969 Tonnage Convention, the 1973 Marine Pollution Convention as amended by the 1978 Protocol (MARPOL 73/78), and others. USCG marine inspectors conduct periodic safety inspections of these vessels to ensure compliance and to ensure that they meet reasonable standards of seaworthiness and structural integrity. These inspections are generally not as extensive as those of U.S. flag vessels, particularly with respect to structural integrity.

1.2 The Inspection Process

Vessels are often inspected overseas, and one inspection trip may involve the inspection of more than one vessel. Most inspections of deep-draft vessels are conducted while the vessel is in a shipyard, but this is not always the case.

Smaller ships, boats, and barges are generally inspected by a single inspector. However, a team of inspectors may be assigned to deep-draft vessels. In the case of a team inspection, the vessel is usually divided up among the team members, with only one inspector visiting each space. If a particularly dangerous space must be inspected or if rafting or another hazardous access technique is used, inspectors may work together. In many cases, inspectors are accompanied by ship's crew members, owner's representatives, shipyard personnel, classification society surveyors or independent surveyors working for the shipowner.

Many inspections take more than one day to complete. During a multi-day inspection the inspector generally issues informal interim deficiency lists called "worklists" to the ship's crew. Worklist deficiencies are often corrected by the crew before the inspection is completed, and if they are, they do not appear on the final inspection report. Inspections conducted during overhauls may extend over a considerable period of time, with repairs and reinspections of those repairs occurring during the overhaul period. Significant deficiencies that can't be corrected before the end of the inspection are scheduled for reinspection at a later date.

On infrequent occasions, an inspection begun in one location may be completed by another inspector or team in a different location. It is not unusual for repairs required as a result of an inspection to be completed in a location other than the inspection port, or in more than one location. In such a case, an inspector or inspectors other than the one who conducted the initial inspection may conduct a reinspection to verify that the repairs were completed properly.

Because of the rotation schedule for uniformed Coast Guard inspectors, it is rare that the same inspector conducts two consecutive COI inspections of the same vessel, or that the inspector who conducted the previous inspection is even stationed in the same geographical location when the next inspection is conducted.

1.3 The Phases of a Typical Inspection

An inspection of a vessel by USCG marine inspectors involves at least four distinct phases, preparation (at the office), the inspection itself (aboard the ship), documentation of the inspection (aboard the ship and at the office), and reinspection of corrected deficiencies. Figure 1 indicates the flow of a typical inspection with multiple inspectors.

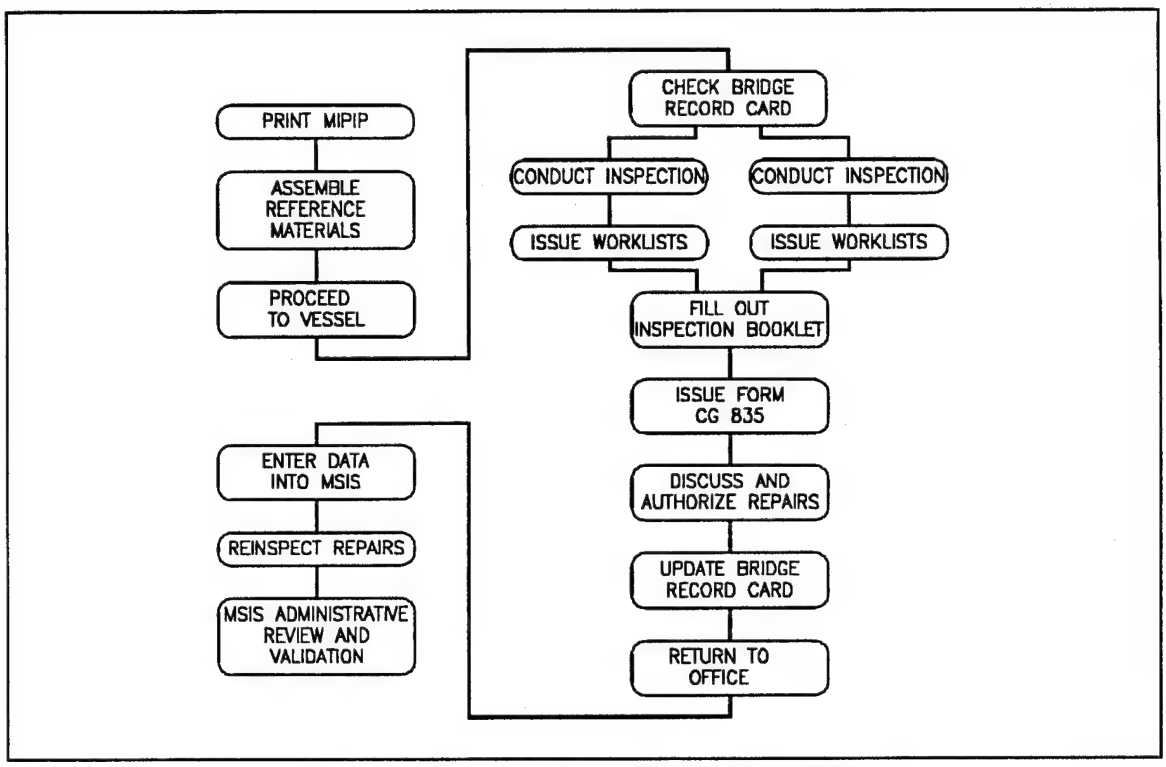


Figure 1. Flow Chart of a Typical Inspection

Preparation Phase:

This first phase of the inspection takes place in the office. The inspector obtains a printout from the MSIS of background information about the vessel's configuration, equipment, machinery, structure, and manning requirements. In addition, the MSIS listing of the vessel's current inspection status is printed out. The combined printout is the Marine Inspection Pre-Inspection Package (MIPIP or "PIP"). If available, records of previous inspections are obtained from files in the office. Vessels are frequently inspected in a port other than the vessel's port of registry, in which case the inspectors may obtain copies of the printed records of past inspections from the CG inspection office in the home port. Other information may be obtained from inspectors who conducted previous inspections, if they can be contacted.

The inspector also assembles a package of regulatory and reference materials (in text form) which might be pertinent to the inspection. These materials are generally carried to the ship by the inspector. Due to space and weight limitations, inspectors are often unable to carry with them all reference materials which might be needed during an inspection.

Inspection Phase:

The inspector (or possibly more than one inspector in the case of larger vessels) proceeds to the vessel. Immediately upon arriving on board, the Bridge Record Card is checked to verify or update the vessel's current inspection status contained in the MIPIP printout.

Pertinent information from the Bridge Record Card may be copied down for inclusion in the inspection records.

Once aboard the vessel, the inspector (or inspectors) generally set up a temporary office in a stateroom or other space where their reference materials and other paperwork are kept, and where they meet with ship's crew and representatives of the vessel owners and the shipyard. The inspector(s) then make the rounds of the ship, recording inspection findings in handwritten or sketch form on a pad. Copies of the inspection booklet may be carried for reference, but the official booklet is generally not filled in until the inspection has been completed.

Documentation Phase:

After completion of the inspection, the inspector (or the inspection team for a large vessel) assembles the notes from the inspection, and completes the inspection booklet (CG-840) appropriate to the vessel and to the type of inspection being conducted. The results of the inspection are discussed with the ship's master, chief engineer, or other crew members. The vessel's officers, in consultation with owner's representatives and shipyard personnel, may propose repairs to correct deficiencies found during the inspection. Repair proposals may be approved by the inspector immediately or may be referred to the Chief of Inspection Department (CID) or Officer in Charge of Marine Inspection (OCMI).

The inspector (or the head of the inspection team) writes the official textual narrative (the *inspection diary*) of the inspection findings. The diary is often handwritten on board, then transcribed to a computer file at the office. Some inspectors who own notebook computers carry them on inspection trips to facilitate preparation of the diary. Before the inspector(s) leave the vessel, a deficiency report (form CG 835) may be issued to the master of the vessel, and the bridge record card is updated.

Back at the office, the inspection book, the inspection diary and a copy of any CG-835 form are placed in the vessel's hardcopy file. Either the inspector or an administrative assistant extracts the appropriate information from the inspection documentation, applies the proper codes, and enters the record of the inspection into the Marine Safety Information System (MSIS) database. At the discretion of the inspector, a narrative synopsis of portions of the inspection diary may be entered into the MSIS as an attached file. After review, editing, and correction by senior administrative officers at the MIO/MSO, the MSIS entries made by the inspector are validated and then become available to all users of the system.

Reinspection Phase:

Repairs to correct deficiencies may be required immediately or within a specified time period after completion of the inspection. These corrective actions are often verified by inspectors. The inspector reinspecting the repairs may not be the same inspector who conducted the initial inspection, and the reinspection may be done by a different office.

1.4 The Marine Inspector's Equipment

Inspectors generally carry a minimum amount of equipment during the actual inspection since crawling into tight spaces and climbing is almost always necessary and any equipment interferes with their mobility. The inspector's tool kit is typically limited to a flashlight, a hammer for scaling rust, a wire brush for removing debris from surfaces, and possibly an inspection mirror. A significant number of inspectors choose not to bring any equipment into a dangerous location like a tankship's cargo spaces which cannot fit into their coveralls pockets or be clipped to their coveralls or belt. Some inspectors carry a small tool bag with a shoulder strap. Such a bag requires some handling and attention and interferes with hands-free climbing.

Protective equipment includes a hard hat, safety glasses, coveralls, gloves, and steel-toed shoes. Safety equipment may include a life vest (when needed), a safety harness, an emergency breathing apparatus, a portable oxygen analyzer, and an explosive gas indicator. Many inspectors choose to do without some or all of this safety equipment because it restricts their mobility.

The inspector's data collection equipment is typically limited to a pencil and a small paper pad. A small percentage of inspectors occasionally use portable voice-activated tape recorders in addition to the pad and pencil.

1.5 Project Origin

The original need for this research project came out of an assessment of a Coast Guard Marine Safety Program Workshop in 1989 in which Marine Safety (G-M) managers were interviewed. The report in Reference (1) defined the problem and technical approach for improving data entry for inspectors and investigators. It was recommended in Reference (1) that the Coast Guard R&D Center address two fundamental problems of data entry and availability *...a means is required for reducing the effort by inspectors to enter information into an inspection booklet by hand. In addition, inspections/investigations could be conducted more effectively if inspectors had ready access to background information, indicating past problems on vessels and systems they are inspecting or investigating.*

Presently, the Coast Guard marine inspector uses pen and paper or standard booklets to record inspection information when in the field. Inspectors often carry along 30 lbs of applicable reference materials which might include U.S. and international regulations, Codes of Federal Regulations, industry rules, etc. There are significant delays in entering completed inspection data into MSIS using the existing paper-based inspection system. This affects both timely availablity of vessel inspection files on MSIS and time devoted by each marine inspector in terms of inefficient administrative work related to each vessel inspection.

The 1992 Coast Guard R&D Center project implementation plan (PIP) described the objective of this effort as ...*the development of technology of source capture primarily for marine inspectors. Whatever, data are collected, they will be consistent with the Marine Safety Network (MSN). It is envisioned that a portable, drop resistant, waterproof, hand-held clipboard computer system will be developed and carried around the vessel by the inspector. This system will collect data either through keystroke entry, bar codes, or voice recognition keywords.This clipboard computer can be connected to a portable PC system containing downloaded MSN data and artificial intelligence (AI) inspection routines. All data can be directly uploaded to MSN back at the office.*

1.6 On-Site Marine Inspection Data Capture - Phase 1

The first phase of this project was initiated in 1992. It involved extensive field surveys to determine the needs of Coast Guard marine inspectors for improved management of inspection data, a specification of rough performance requirements based on these surveys, and an identification of non-developmental hardware and software that could satisfy these requirements. The project consisted of five distinct tasks. They were:

- Questionnaire Development
- Field Survey
- Inspector Workshops
- Development of Functional Requirements
- Survey of Nondevelopmental Hardware and Software

The Phase 1 study, Reference (2), made the following general conclusions in terms of a conceptual main portable inspection capability.

On-site Computer:

The Phase I report recommended that inspectors be provided with a pen-based computer for use while conducting inspections. This computer would implement an computerized adaptation of the particular CG-840 series inspection booklet appropriate to the inspection being conducted. The computer would prompt the inspector for responses to standard entries, and would allow entry of sketches and textual comments. The program would store the entered data in a database for use with the on-site computer, the on-board computer, and a home-office computer which prepares a record of the inspection for storage on the marine safety database.

The on-site computer would also provide for searching and display of reference and regulatory materials which are frequently used by inspectors.

On-Board Computer:

A keyboard-based notebook-type portable computer, carried on board the vessel to be inspected, but not carried by inspectors while actually conducting an inspection, was

recommended as an on-board base station. Data collected by the on-site computer (or more than one on-site computer in the case of inspections conducted by more than one inspector) would be merged by a program in the on-board computer. The on-board computer, in addition, would provide access to a more extensive database of reference and regulatory materials than could be accommodated by the on-site computers, and would be used for word-processing tasks such as filling out and printing forms and creating the inspection diary. The software would allow sketches prepared on the on-site computer and digitally stored photographs to be included in the diary.

The on-board computer would have an internal hard drive and floppy drive, and would connect to an external removable hard drive and to a CD-ROM unit. The collected inspection data would be stored on the removable hard-disk drive of the on-board computer. The removable drive allows the records of the inspection to be transferred from the on-board computer to a desktop workstation connected to the marine safety database. The home-office workstation would provide any necessary format conversion between the inspection system and the marine safety database. At the time of the Phase 1 report, laptop and pen computers had small hard drives and many had no floppy drives. Also, the size of inspection files was expected to exceed the capacity of a single 1.44 MB floppy disk.

Inspection Records:

It was recommended that the digitally stored inspection record file in the marine safety database (which may also be stored for back-up purposes at the inspection office) be designated as the official record of the inspection. Paper copies of inspection records would no longer be kept.

Computerized storage of information would allow a greater amount of information about each vessel (including plans) and more detailed records of past inspections to be kept and made available to inspectors. Most of the vessel information and past inspection records would be available to users of the marine safety database at locations other than the vessel's port of registry.

Pilot Project:

It was recommended that a pilot project (technology demonstration) be conducted to test the concept of computerized inspection data management and to evaluate the strategies proposed in the Phase I report. The pilot project should be limited in scope with respect to the types of inspections covered and in the extent of the custom-developed applications. This would allow the project to be implemented quickly and with moderate expense. However, within the limited scope, it was recommended that the project include a wide range of hardware and software and expose these to as many inspectors as possible.

1.7 Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU) - Phase 2

Phase 2 of this research was initiated in 1994. It involved taking the rough requirements developed in Phase 1 and building a working prototype that could be used to evaluate various issues surrounding the use of a computerized inspection capability for Coast Guard inspectors. Much of the work done in Phase 2 was contracted out. Phase 2 results are documented in Reference (3). The Coast Guard requirements for this phase included:

Prototype System Configuration. This task required the contractor to assemble and develop two prototype MPIU systems which best fulfilled the performance requirements. The MPIU systems were required to perform the following functions:

- implement the computerized version of the inspection booklets on the pen computer;
- transfer programs between the laptop and pen computers;
- provide access to a large database in a CD-ROM unit attached to the laptop;
- transfer collected data from the pen computer to the laptop computer;
- merge data collected by more than one pen computer into a single database;
- combine data collected by pen computers with diaries and other documents (prepared on the laptop into a final inspection datafile) and
- fill in and print out records of the inspection.

The transfer of data to and from the marine safety database was not addressed as part of the technology demonstration. The project focused on implementing two inspection booklets, the Tankship Hull Inspection Book and Barge Inspection Book. These spanned the range between very complex tanker inspections and the relatively simple barge inspections. The contractor was also required to provide computerized access to a limited amount of reference material, primarily information from the Code of Federal Regulations.

Field Unit Testing This task was conducted by a Coast Guard field unit (New Orleans Marine Safety Office). The contractor was to provide the hardware, software, user's manuals and training to permit the trial to take place. The contractor was also to provide hardware and software support during the field trials. The extent to the trial period was two months. This was later extended to about 2-1/2 months.

Evaluation of Field Unit Impact This task required the contractor to evaluate the effectiveness of the MPIU in its overall ability to streamline the Coast Guard ship inspection business and document marine inspector feedback. The contractor was also required to evaluate the impact on safety and mobility of inspectors when using this technology.

The principal goals of the Phase 2 MPIU technology demonstration were to:

- Allow inspectors to evaluate the concept of computerized inspection data management and to document their feedback on how effective it is in streamlining the business of ship inspection documentation;

- Evaluate the hardware and overall concept of computerized inspection data collection under a range of environmental conditions including adverse lighting conditions, temperature extremes, exposure to oil and other factors; and

- Identify the extent to which carrying a portable computer affects an inspector's safety and mobility.

The pilot study also afforded the opportunity to:

- Evaluate the suitability of the particular commercial software packages chosen for the pilot study and

- Evaluate, by actual experience, the level of effort required to develop custom inspection applications.

The main limitation on the technology demonstration was the lack of an interface with the marine safety database which prevented the inspectors from testing the principal time saving feature of the MPIU system predicted in Phase 1. However, it was impractical to produce this interface in the time frame for this phase of the project.

In general, inspectors were enthusiastic about the potential for computer-assisted inspection data management, and saw the systems and software provided during this project to be a useful first step toward achieving that potential. The users of the MPIU systems repeatedly stressed four principal themes: first, the need for a two-way interface between the MPIU system and marine safety database; second, that the system-based, checkoff-box oriented design of the MPIU inspection programs needs to be changed to a compartment-based design with more emphasis on recording deficiencies; third, that carrying a computer around a vessel during an inspection is impractical but having one available on board is very beneficial; and, fourth, that computerized access to reference materials is the most valuable function from the inspector's viewpoint.

The lack of a direct interface between the MPIU programs and marine safety database affected both the manner in which the inspectors used the MPIU software and their evaluations of the system, especially with regard to the time required to conduct inspections with the system. There was a built-in duplication of effort required, since any information the inspectors entered into the MPIU programs had to be re-entered manually into marine safety database if it was to become part of the inspection record. This discouraged inspectors from using comments or diary entries in the MPIU programs.

The inspectors using the system felt that it afforded little to no savings in time over paper-based data collection. It should be noted that the purpose of the MPIU system was not to save time on board ship but rather to save time back at the office when interfacing to the marine safety database. This feature was not part of the technology demonstration in Phase 2. Thus, the true savings that the MPIU system provides could not be evaluated by the inspectors.

Inspectors want the MPIU to be an extension of marine safety database. They would like to have the ability to:

- Upload the information which they currently print out from the marine safety database into the portable computer with a minimum of on-line time for the inspector.

- Automatically fill in and print all marine safety database-related forms on board the vessel being inspected.

- Perform marine safety database functions such as deficiency coding on the portable computer system, in a more user-friendly environment than the current marine safety database provides.

- Download completed inspection data to the marine safety database with a minimum of on-line time for the inspector.

Inspectors should be able to perform on board the vessels, using their portable computers, most of the functions now accomplished at the marine safety database terminals in the office. Tasks such as coding of deficiencies should be done on the portable computer using pull-down menu picks and other enhancements. The transfer of vessel information and past inspection records from the marine safety database to the portable computers and of inspection data from the portable computers to the marine safety database should be streamlined to require as little office time and inspector interaction as possible. This will provide more time on board for inspections or allow a reduction in the inspection work force.

The users would like the hardware to be chosen to more closely reflect their actual needs. They recommend that the MPIU system:

- Abandon the carrying of a pen-based computer as a fundamental premise of system design. Base the system on a portable pen-capable system which is primarily designed for desktop use but which can be carried if desired.

- Provide a durable integrated system case with space and adequate battery power for the computer, the printer, and the camera.

- Continue support for digital photography, preferably in color, and streamline the transfer of pictures from the camera to the computer.

- Delete the little used CD-ROM from the system to reduce weight and complexity.

A carrying case/portable office is a practical solution adopted by many people that have to travel frequently. Independent batteries will be needed for each piece of equipment so that the camera and pen-computer could be used away from an office environment. However, a common power supply is a practical alternative. This supply should accept U.S. and foreign power inputs and supply EMI, RFI, surge and spike protected power to all units in the system via short power cords with appropriate terminal connectors. Some equipment requires DC power that would need to be rectified by the power supply and output at the correct voltage. The power supply should be flexible enough to accommodate reasonable changes in MPIU hardware from time to time.

The users recommended three major changes to the MPIU inspection programs:

- The adoption of a compartment-based organization instead of the present system-based organization.

- A change in focus from checking off satisfactory items to recording deficiencies, including abandonment of the check-off boxes for individual inspection items.

- More visual and graphical assistance in navigating the structure of the program.

All three of these suggestions may have merit. However, it would be prudent to conduct additional technology demonstrations and a larger pilot project involving many more inspectors before drawing conclusions on these issues. Changing to a compartment based organization requires significant work to determine which systems are likely to occur in which compartments or even to determine generic lists of compartments for a given type of ship.

Classification societies have adopted checkoff lists to force their surveyors to verify items in detail. This was done to promote uniformity between surveys in different parts of the world. Their surveyors had much the same reaction to this change that the inspectors in MSO New Orleans had to more detailed check boxes in the MPIU programs. The choice is really between allowing inspectors more discretion when evaluating systems overall or enforcing uniformity by requiring detailed checkoffs. This is a management decision that must be made before the final MPIU system is implemented.

Users were enthusiastic about the potential of the inspection computer system to facilitate access to the large volume of reference materials required by inspectors. However, they

found little use for the simple word-search access to a limited database which was provided with the MPIU system. Reference access should be more fully developed, and the reference access and data collection functions should be more closely integrated, preferably by direct context-sensitive, i.e., hypertext, access to the reference material from the inspection programs. Additional reference material should also be incorporated including the Marine Safety Manual, Navigation Inspection Circulars (NVICs), international rules, Marine Compliance Office (MCO) policy letters, OCMI instructions, the equipment list, and possibly classification society rules. It would also be beneficial to include any waiver letters in individual vessel files.

Inspectors did carry the pen-computers with them in some tank and machinery space inspections, but concluded early on that they preferred to keep the equipment secure in an office environment either aboard ship or in a shipyard office. Therefore, a thorough evaluation of the effect on safety and mobility was not performed and only limited conclusions can be drawn from the technology demonstration. The inspectors remain open to trying improved carrying systems and all agreed that they would use an improved system when a mobile inspection was warranted. They were also afraid of damaging an expensive piece of equipment when maneuvering through tight spaces or climbing ladders. Inspectors did not consider the fact that the computer or camera was unsafe in hazardous locations to be a serious limitation.

In Phase 2, it was recommended that as many as possible of the changes discussed be made to the MPIU system, followed by another, more extensive, field trial. This field trial should be conducted in an office where the current inspection procedures are still based on the inspection books. Training of inspectors by other inspectors did not work well in the New Orleans field trials; therefore, more time should be devoted to adequate training of all users before future trials.

Phase 2 Recommended Changes to the MPIU Hardware:

Assembling a system (computer, printer, CD-ROM, cameras, etc.) in modular fashion from standard off-the-shelf hardware has many advantages in terms of flexibility, adaptability, and easy replacement and upgrading of individual hardware components. However, when most of the components are battery powered, the user must expend considerable effort and pay close attention to ensure that all batteries are charged at the beginning of an inspection and that spare charged batteries are ready when needed. The modular approach also requires a number of data connections, most of which require cables, and these cables are typically much longer and bulkier than necessary.

First of all, it is recommended that this modular strategy be maintained. The technology of portable computer equipment is progressing rapidly, and it is important that the obsolete or damaged components of the system can be easily replaced or upgraded without affecting the rest of the system. However, a higher level of hardware integration is needed to eliminate the number, size, and weight of chargers and cables. While no need for custom-designed computers, printers, or other important peripherals is anticipated, a

carrying system with an associated combined power supply and short cables for connecting all equipment, should be specifically designed and built for marine inspection application. Because inspectors often board foreign vessels at sea, the carrying case should survive shocks over and above those of the individual components shock tolerance.

The CD-ROM is no longer needed as a means of referencing large databases. The size of reference databases used routinely by the inspectors can be accommodated on computer hard drives. Therefore, this additional piece of equipment with its data cables and power supply should be eliminated.

Based on inspector responses in the technology demonstration, future systems may not require both a small hand-held computer like the Dauphin and a laptop computer. Further field evaluation is needed to verify the inspector's preferences regarding computer size. If the larger pen-computer is preferred by the majority of inspectors, the inspection system could consist of one pen-based computer which can be hand-carried when the inspectors desire and can also serve as an office-based laptop computer with a keyboard and mouse. The latest model of the Compaq Concerto (an earlier model was used in this project) comes very close to fulfilling this need. However, a color display may be desirable.

Pen-computers and color graphics are rapidly evolving technologies. Advances in these fields are continually making mobile computerized data collection more feasible and less expensive. Until the MPIU system is ready for widespread implementation, there should be a continuing program to ensure that the most advanced hardware which is available off-the-shelf is integrated into the system. For example, color digital photography is a rapidly maturing technology that could offer significant improvements over the monochrome digital photography used in the first-generation MPIU system.

Color would show more detail than black-and-white, especially during inspections in spaces such as ballast tanks or double bottoms where corrosion or deterioration of surface coatings are often indicated by the color of the surface. Color laptop and pen computers are available and their prices are quickly falling to reasonable levels. Color digital cameras are also available and affordable.

2 Introduction

2.1 Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU) - Phase 3 Research Goals

The Phase 2 evaluation involved a technology demonstration with only a few marine inspectors. A second iteration of a technology demonstration was needed to further refine the software for testing in the field to increase the confidence in the functional requirements to be developed. Some specific goals of Phase 3 evaluations were:

- Evaluate advances in portable computer technology
- Evaluate the potential of employing voice recognition technology

- Evaluate the prospects of interoperability with Classification Societies
- Evaluate the cost/benefit associated with a Coast Guard MPIU capability (this goal is being addressed in a separate published report)

2.2 Overview of Contracted Studies

In Phase 1, MAR, Inc. was contracted under the Coast Guard R&D Center Marine Engineering Branch's (MEBs) Indefinite Delivery Indefinite Quantity (IDIQ) to perform field survey and workshops to determine a basis for developing a prototype portable inspection capability. In Phase 2, MAR, Inc. was contracted again using MEBs IDIQ to develop a working prototype that could provide a limited field demonstration to some inspectors from MSO New Orleans. Phase 3 contracted efforts involved a number of contractors who were competitively awarded small purchase contracts. Patriot Systems developed the enhanced version of the MPIU system with the electronic reference library. The cost/benefit evaluation was limited to MIO New York. Engineering Technology Center, Inc. developed a specific MPIU voice recognition capability for field demonstration purposes. Table 1 summarizes the research participants.

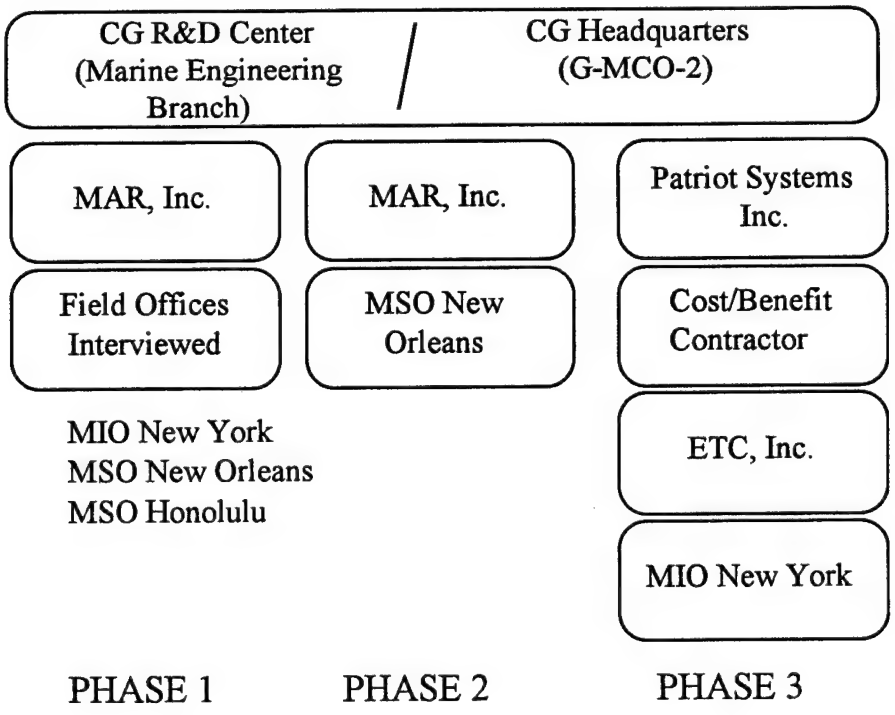


Table 1. Research Participants

3 Marine Portable Inspection Unit (MPIU) Software Enhancements

3.1 Phase 2 MPIU Software Overview

In Phase 2, a contractor developed computer programs designed to replace the functions of the Coast Guard's Tankship Hull Inspection Book (CG-840S of 7-78) and Barge

Inspection Book (CG-840E of 2-79) (on pen-based computers). These new computerized inspection books ran under Microsoft Windows for Pen Computing. The tankship and barge programs are separate programs, but they are based on a common library of source code developed specifically for the MPIU project. The software was written using the Professional Edition of Microsoft Visual Basic for Windows, Version 3.0. Additional programming capabilities were added with a third-party Visual Basic enhancement package, Sheridan Software's VBAssist, which speeded the development process.

Many of the differences in appearance and function between the tankship and barge programs were created by configuration data files which are loaded by the programs when they are executed. The configuration files begin as plain American Standard Code for Information Interchange (ASCII) text files. When the MPIU program is first executed, the configuration information in these files is compiled and stored by the program in a more efficient format. During subsequent runs the program uses these compiled configuration files, which speeds loading and execution. A few of the differences between the tankship and barge programs which cannot be controlled by configuration files are hard-coded.

The programs closely follow the organization of the inspection books, using topics such as firefighting, cargo handling, personnel, pollution prevention, etc., as major categories. The primary divergence from the format of the paper inspection books occurs in the tankship program. In the paper tankship book, some topics are repeated in the "U.S.", "Foreign", and "U.S. and Foreign" sections. These multiple occurrences of inspection topics have been consolidated in the inspection programs, so that the proper entries are automatically displayed for the flag of the ship being inspected. In many cases, especially for vessel information sections, the appearance of the computer screens is similar to that of the pages of the inspection book.

The inspection book programs are designed primarily for pen-based computers, but they can also run on laptop or desktop computers (with the loss of the pen-sketching functions). Some of the important features and capabilities of the software are:

Loading vessel background information from previous inspections. Many entries are not expected to change from one inspection of a particular vessel to another - this feature eliminates the need for re-entry of information which is unlikely to change over one or two years.

Recording inspector responses to individual check-off items. "SAT/UNSAT/NA" are provided for each inspection check-off item. These items correspond directly to bulleted items in the inspection books. They are checked by a simple tap of the pen. These entries are "grayed-out" (inactivated) when they do not apply because of the vessel's flag.

Recording text comments. Multiple text comments can be created and linked to each individual check-off item. Text entry is done by printing on the screen with the pen, resulting in "ink" which is recognized by the system and stored as standard ASCII text.

Text can also be entered into comments with a keyboard. Each comment is assigned one of three states: "Open," "Cleared," and "General," and these states can be changed by the inspector at any time. "Open" comments are treated in the same way as "UNSAT" checkmarks. Comment status allows implementation of a narrative-based inspection, as now practiced by several inspection offices, without sacrificing the automatic identification and processing of deficiency information by the report-generation module of the program. In addition, "Cleared" comments allow information about deficiencies found at the beginning of an inspection, but corrected during the course of an inspection, to be retained as a record, in accordance with the latest G-MVI inspection documentation policies. Comments can be edited at any time.

Recording of sketches. As with comments, any number of freehand sketches made with the pen can be linked to any individual check-off item. These sketches can be edited at any time. The sketching function is only available on pen-based computers since this capability is not provided under Windows 3.1 software, only under Windows for Pen Computing.

Use and Annotation of Digital Photographs. Digital photographs can be linked to any check-off item and can be annotated by the inspector by sketching with the pen over or alongside the photographic image.

Annotation of Other Images. Like photographs, pre-existing bitmap images of drawings such as vessel arrangement plans or structural details can be linked to check-off items and, like photographs, they can be annotated by pen sketching.

Report generation. Both hard-copy and disk file reports can be generated, and they can include: all outstanding deficiencies; all outstanding and cleared deficiencies; or all check-off fields. Deficiency reports can be used by inspectors as worklists which are issued informally to a ship's personnel during an inspection. Report fields are labeled with the name of the item, the subtopic and main topic which contain the item, and the status of the item. Comments, sketches, and photographs linked to check-off items can be printed with any type of report at option of the inspector. The existence of comments and "inks" is noted for each item in a report even if the comments and inks are not printed.

Merging Inspection Files. When a large inspection is conducted by more than one inspector using more than one pen-computer, the resulting independent inspection files can be merged. Many entries are automatically combined according to certain logical rules. The inspector is prompted to edit or choose between duplicate or ambiguous entries.

The inspection programs store inspection data in several files. The principal data is stored in an ASCII database format. The data file for each inspection is a single record and each item of information is a single field in that record. Several types of data are retained in the inspection database file: the states of the SAT/UNSAT/NA checkboxes, any text or numbers entered as data or comments, digital "ink" entered as sketches or annotations to template drawings and photographs. In addition to the inspection database, digital

photographs and template drawings are stored as independent bitmap files, the rough inspection diary is stored as an independent ASCII text file, and another file stores the settings of the status indicators in the program which show, on each screen, the existence of deficiencies and incomplete entries on any subordinate screens.

Figure 2 illustrates the hierarchical structure of the MPIU programs. Inspection topics are selected using a button bar on the main form which is always in view. Figure 3 shows this button bar. Figure 4 shows a typical first-level form. This form contains buttons for selecting second-level forms and a brief description of the content of the second-level forms beneath it.

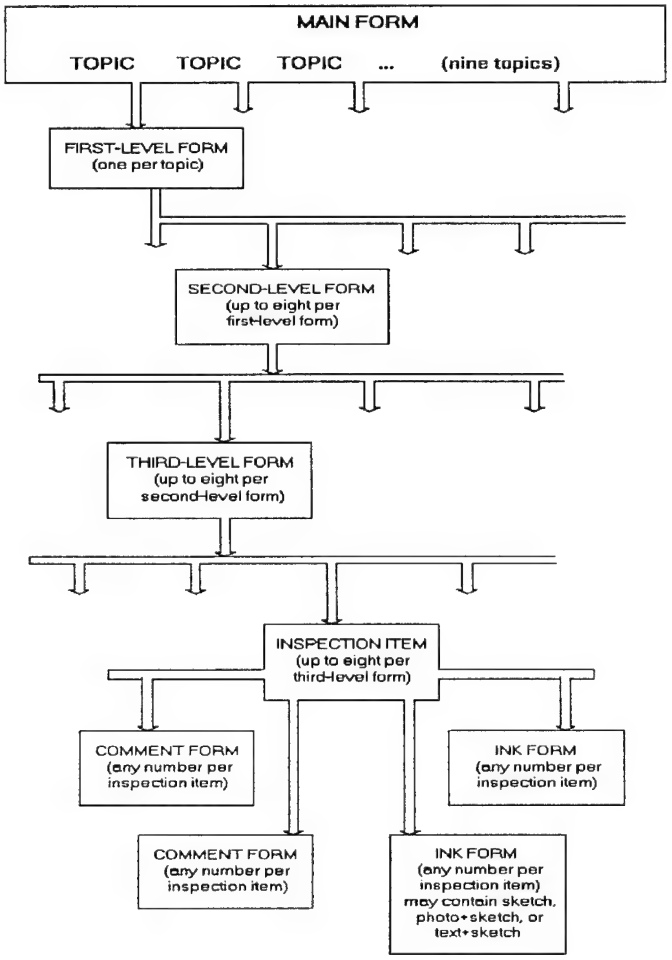


Figure 2. Logical Organization of the MPIU Programs

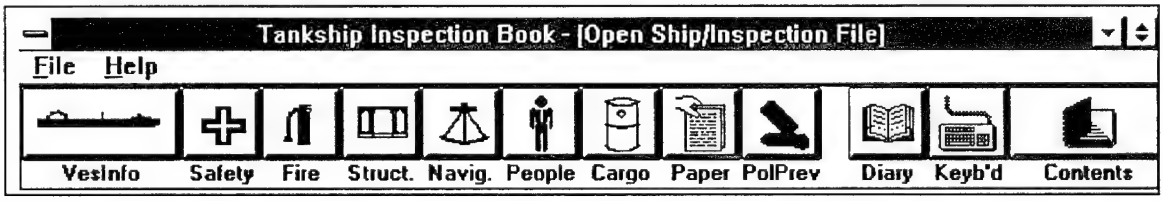


Figure 3. Upper Part of Main Form for Tankship Program

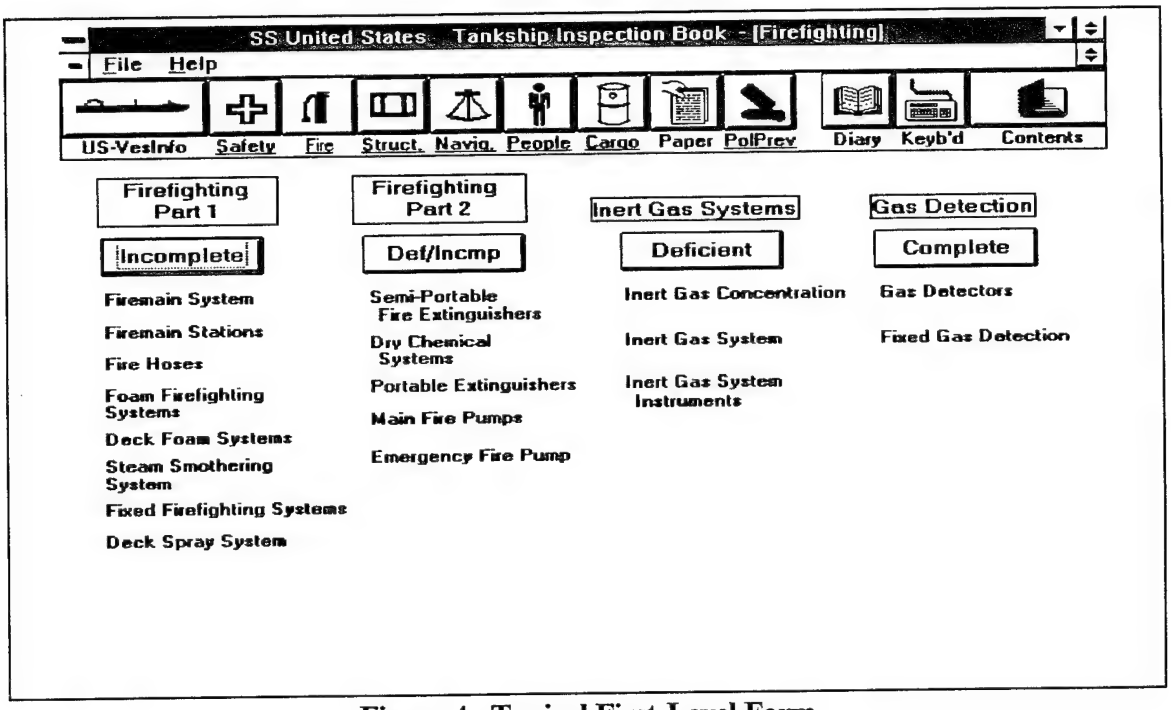


Figure 4. Typical First-Level Form

A typical second level form is shown in Figure 5 with its topics and selection buttons for the related third level forms. A typical third level form is shown in Figure 6. Comments and inks can be attached to each line item on this form. The small "C" and "I" to the left of the buttons indicates that there are comments and inks currently attached to a line item. An example of a sketch attached to an inspection item is illustrated in Figure 7. The inspector can call upon commonly used bitmap file drawings to annotate with the electronic pen.

More detailed information on program function is contained in Reference (5) User's Manual.

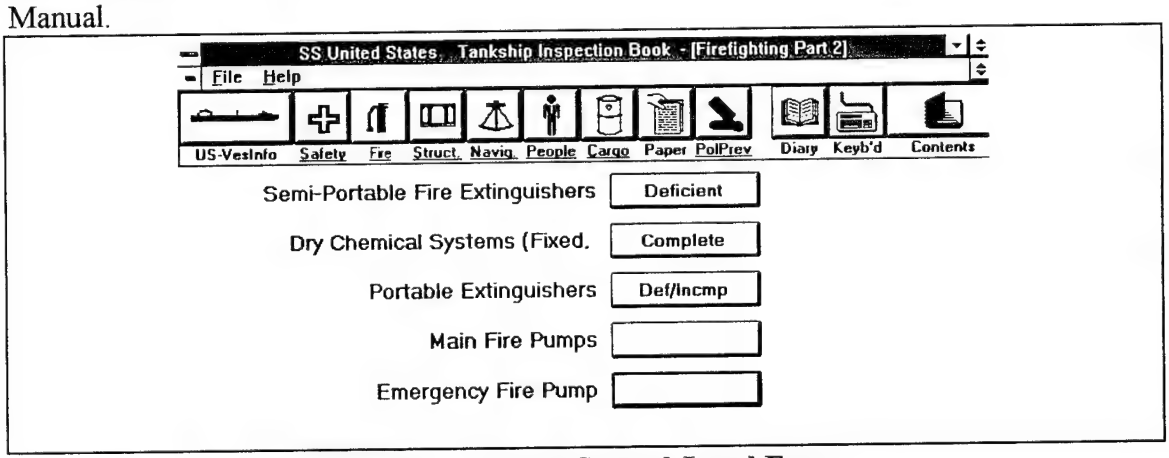


Figure 5. Typical Second-Level Form

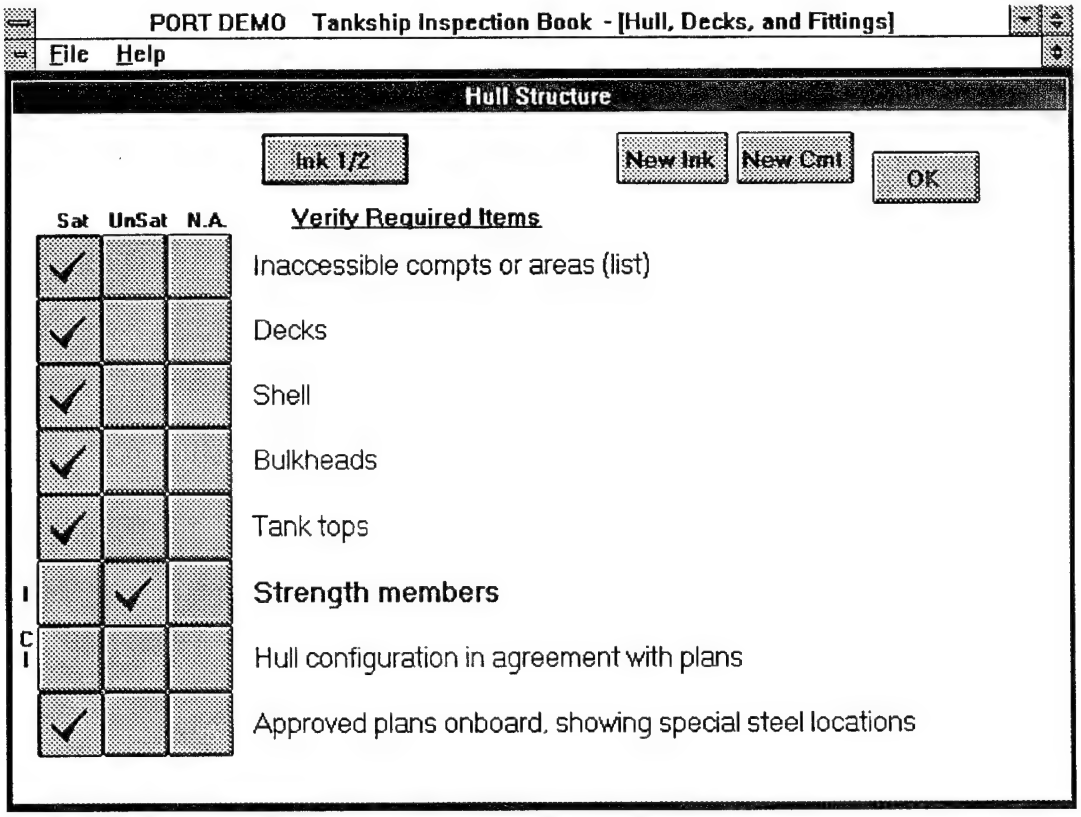


Figure 6. Typical Third Level Form

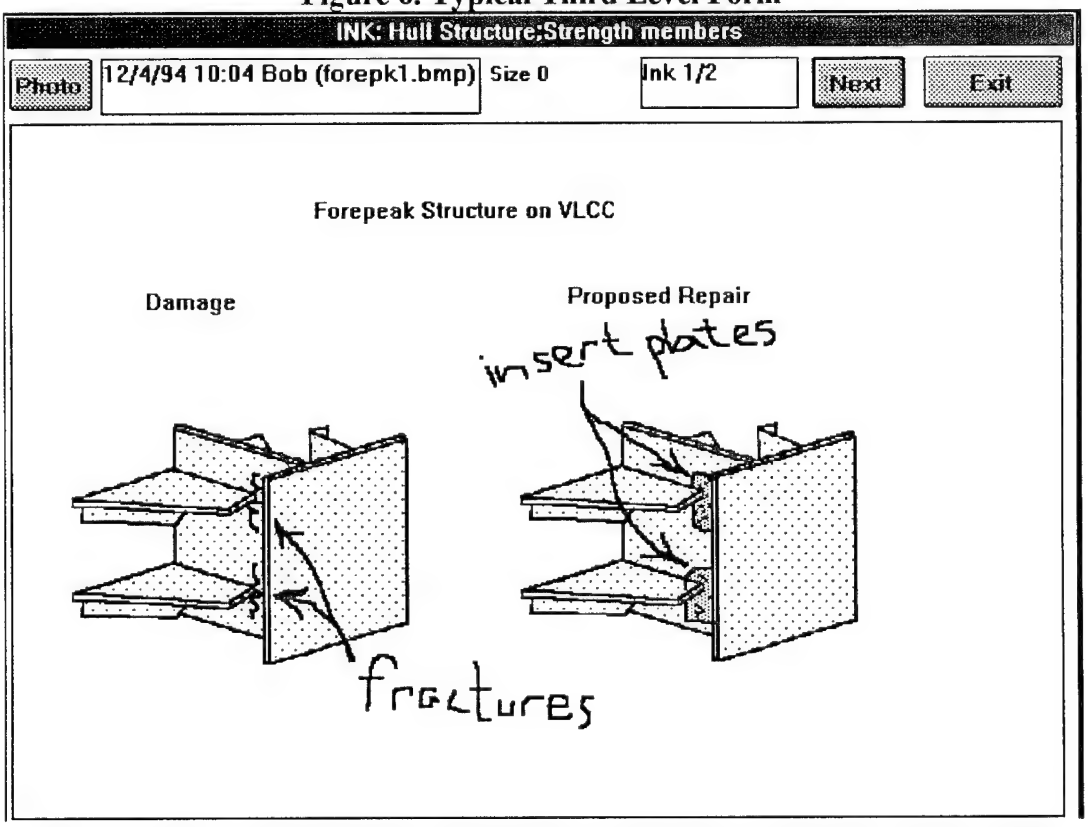


Figure 7. Typical Pen Sketch Attached to a Third-Level Form Inspection Item

3.2 Phase 3 MPIU Enhancements Overview

Spindrift Reference Library

In Phase 2 inspectors were not impressed with the elementary word search access to the limited CD-ROM reference library provided. It was not convenient or efficient to exit the MPIU program and access a separate drive to view the regulations of interest. However, inspectors considered a fully developed reference access capability to the large volume of reference materials to be extremely important to the practical utility of a field MPIU system. These concerns were addressed in the development of a larger reference library with direct and efficient access through hypertext or key-word searches directly from the MPIU inspection program. A prototype program called 'SpinDrift' under development by Patriot Systems based on Folio Bound VIEWS Version 3.1 seemed to have many of the desired features. The R&D Center contracted for the expansion of the reference library for the Phase 3 technology demonstration at MIO New York.

Linked Reference Library

The reference library called 'SpinDrift' contains a demonstration of the types of reference material that a marine inspector might need out in the field. Phase 3 software allows the user to launch directly into 'SpinDrift'. The inspector can conduct his reference search and quickly revert back to the electronic inspection booklet. Hypertext links from electronic inspection book memory joggers to the 'SpinDrift' reference library are available as a convenient tool for regulation verification.

MIPIP to MPIU Interface

A MIPIP to MPIU interface was developed for both Phase 2 and Phase 3 software. The interface developed was limited to converting a CTOS formatted disk with a MIPIP print file for importation into the MPIU software using the CGSW's MSDOS WRITE program. A direct communication between the MPIU and CGSW is possible using a null modem cable. The list below outlines the action taken for each of the subsections of the MIPIP for the Phase 2 software developed by MAR, Inc. Possible actions include copying the text to the diary, selecting values for variables, or no action. In some cases the diary is used with variable selection.

MSIS	Subroutine	Diary	Variable	No Action
VFBD	Boiler_Details		X	
VFCA	Cargo_Authority	X	X	
VFCS	Cargo_Specifications	X		
VFCC	Cond_of_Carriage	X		
VFCD	Construction_Dets		X	
VFCG	Contact_Log			X-Code is included for diary but commented out
MICP	Critical_Profile	X		
VFDL	Damages_Defects	X		
VFCL	Dangerous_Cargo_Auth	X		
VFDM	Deck_Mach_Details		X	
VFDD	Design_Details		X	
VFED	Electrical_Details			X
VFFF	Fixed_FF_Details		X	
VFHD	Hull_Details		X	
VFIP	Involved_Party		X	
VFLS	Lifesaving_Details		X	
VFMD	Measurement_Details		X	
	MIPIP-General		X	
VFMS	Misc_Systems			X
VFND	Nav_Details			X
	Open_Cases	X		
VFOD	Operating_Details		X	
VFPF	Port_FF_Details		X	
VFPV	Pressure_Vessels		X	
VFPP	Propulsion_Details		X	
VFPD	Pump_Details			X
VFLD	Safety_Reg_Docs	X	X	
	Scheduled_Insp	X		
VFSL	Stability_Details			X
MSID	Status_Details	X	X	
	Status_Summary	X	X	
VFSD	Steering_Details		X	

The number of variables written to the MPIU will be different for the Barge and Tankship Programs. In both Phase 2 and Phase 3 programs the entire text of the PIP can be viewed within the MPIU software.

Deficiency Database

A simple field level database was developed for tracking the deficiencies recorded in the MPIU program. This feature is in the Reports section of the MPIU program. It allows the user to generate custom reports using all of the inspection data at his disposal. The inspector can choose to perform a sorting of deficiencies on a single vessel or all of the vessel inspections available on the computer. The inspector can further sort the data by viewing all deficiencies or just open deficiencies on all classes of vessels or a specific vessel. The inspector can also retrieve a Certificate History File, Case Report, or Deficiency History.

Not Observed Category

The inspectors at MSO New Orleans (MSONOLA) involved in Phase 2 suggested that a "Not Observed" category should be added to the existing "SAT/UNSAT/NA" checkboxes. This would account for spaces which were not available for entry, systems which were under repair and could not be tested or inspected, etc. This was addressed in Phase 3 software.

Digital Photograph Features

In the Phase 2 software the linking of digital photographs to inspection items was limited to black and white bitmap files only.

Phase 3 software allows for a variety of picture images including TIFF, PCX, and vector images from CAD using CAD standard DFX file format, to be conveniently linked to inspection items.

MPIU to MPIU Interface

In Phase 3 an interface was developed for transmitting selected inspection files between the pen-based and laptop computers using built in modems. The communication interface is capable of transferring and receiving data between PC based systems via direct parallel ports and modem serial communications. The routine will support ZModem, XModem, Kermit, and YModem file transfers.

Field Printable Inspection Certificates

Inspectors often have to issue various paper forms to vessel owners during or after an inspection. Carrying these forms can be troublesome and filling them out can be time-consuming. It was determined that it would be helpful if the computer system was able to print out most of the commonly used forms, such as temporary Certificates of Inspection, Permits to Proceed, SOLAS certificates, MARPOL certificates, etc. A good deal of the information which is presently entered manually on these forms by the inspector will be available in the files uploaded from the marine safety database at the beginning of the inspection, and could be used to automatically fill many of the fields on the forms. The remaining information could be entered by the inspectors into the computer, and then the forms could be printed out on-site for signature and issuance.

The inspection certificates selected for use in this evaluation are:

- CG-854 Temporary Certificates of Inspection (COI)
- CG-840S-1(and -2) Tank Vessel Examination Letter (TVE)
- CG-5352 International Oil Pollution Prevention Certificate (IOPP)

The ability to electronically issue and print an CG835 deficiency was included. The electronic certificates are automatically updated with available information collected as part of the MPIU inspection file. A preview option was included to review the information on the certificate and the ability to edit its contents before printing to file or to a printer.

The Phase 3 software includes a history file which includes each issued certificate. Each certificate has a letter number combination printed in the lower right hand corner to identify the certificate for tracking purposes. For example, MIONY-JI-COI-01-0001 which would indicate Marine Inspection Office NY(MIONY), inspector Joe Inspector(JI), Certificate of Inspection(COI), MPIU No. in use(01), and a sequential number(0001).

Template Drawings

During the Phase 2 work, inspectors often commented that it would be very helpful if the drawings of the vessel being inspected were available on an inspection computer system for reference during an inspection. During the course of the field trial, and as a result of discussions with inspectors about techniques for recording structural deficiencies in tank vessels, the contractor prepared a 3-dimensional drawing of a typical tank vessel's hull construction. A number of overall and detailed perspective views were produced from this drawing and were used as background templates for ink forms in the tankship program. In Phase 2 software, only background images (such as digital photographs) which are stored in a specific vessel's inspection directory, were available to ink forms as background.

4 Voice Recognition Technology Demonstration

4.1 MPIU Voice Recognition Development

It was determined based on field response that portable computers, no matter how lightweight and compact they may become, would not be used in specific areas of the vessel where the inspector's safety is of primary concern. In certain areas of a vessel, such as in tank/double bottoms spaces of tankships and barges, inspectors can't be burdened with extraneous gear. Normal portable computer assisted inspection is not possible for these aspects of an inspection with the present MPIU concept.

Speech recognition technology suits those applications where the user needs an alternative to using his eyes or hands. An example of this would be dialing a cellular phone while driving. Safety is the main concern in this instance and voice recognition or ASR (automatic speech recognition) is the best approach to making a connection. The technology is here, in various forms, from assisting people make electronic menu selections to text-to-speech synthesis. However, the technology is not sophisticated to the point where it can understand casual conversational speech.

There are generally two forms of speech recognition models. They are speaker-independent and speaker-dependent systems. The speaker-dependent systems provide

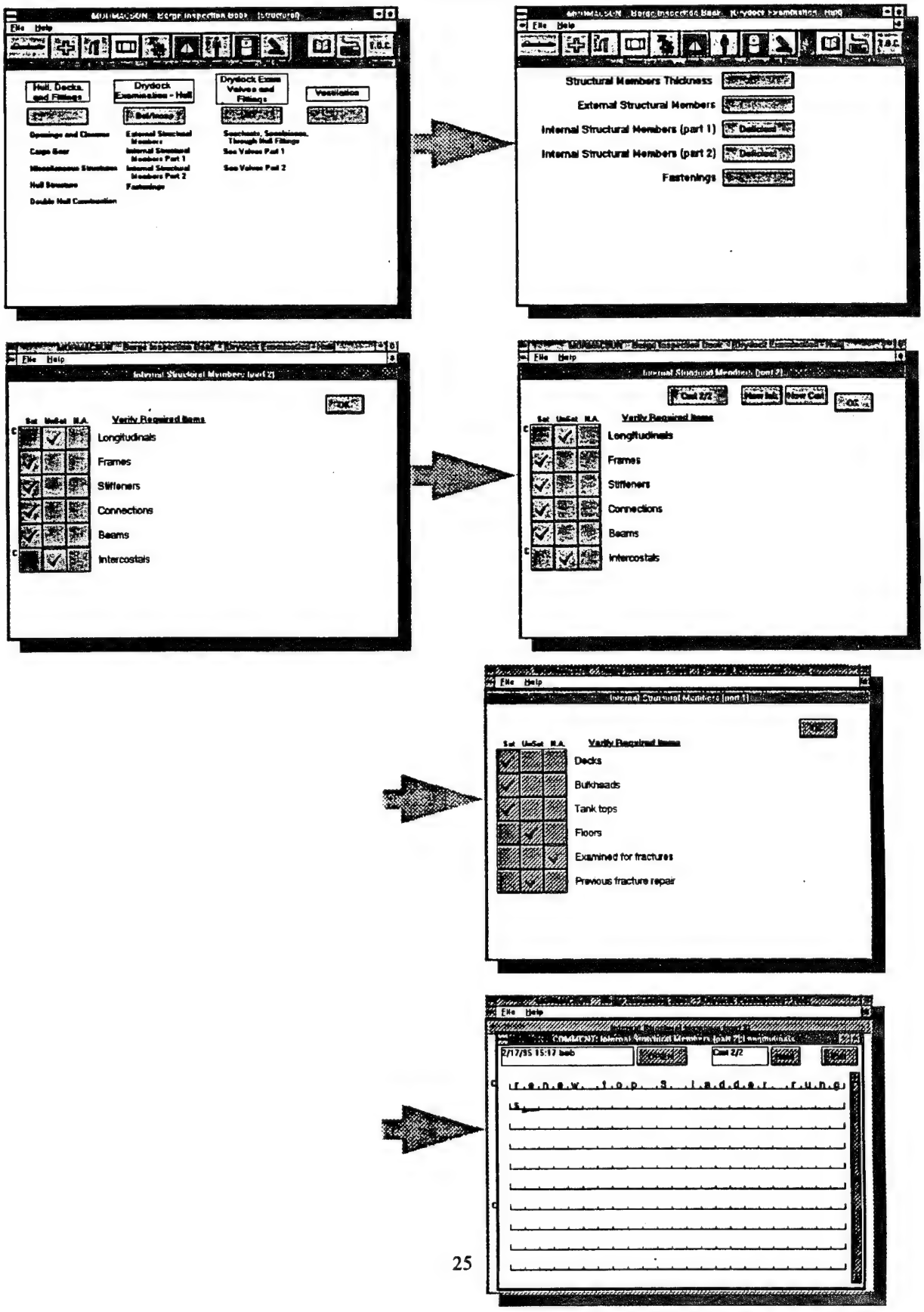
better recognition reliability and allow the users to customize the vocabulary and pronunciation. In a speaker-dependent system, training prompts the user to speak a command word at least twice and then stores the average in a template. This is the approach chosen for this technology demonstration.

A contractor was tasked under a small purchase agreement to develop a limited technology demonstration of voice recognition technology applicable to Coast Guard marine inspection. The contractor was required to integrate a voice recognition capability with the MPIU system. The element of the MPIU that was integrated with the voice recognition system resides within the "Dry-dock Examination-Hull" form in the Barge Inspection Book. The contractor was tasked to configure the system to enable the laptop to be placed near a tank opening and for an inspector to enter the tank wearing a microphone radio link. The inspector would indicate that he is collecting information under the "Internal Structural Members" inspection category. The contractor was required to develop the ability to collect associated information under this category. Figure 8 illustrates the equivalent MPIU pen driven barge dry-dock examination screens that were converted to a voice capability. The conceptual scenario for collecting this information was described as follows:

The inspector selects an internal structure type that he is looking at, e.g., "Longitudinals," "Frames," "Stiffeners," "Connections," "Beams," or "Intercostals". For example,the inspector might select "Longitudinals" and then record any deficiencies noted. If the inspector wants to denote a deficiency the inspector might say "longitudinal comment number one" and after confirmation from the voice recognizer would proceed with the comment. After finished noting deficiencies the inspector would indicate the status of that inspection category by saying that it is "Sat," "Unsat," or "Not Applicable". There is the requirement of confirmation from the voice recognizer that an inspection category was complete.

For the comments recorded in the technical demonstration the voice recognizer was required to be trained to recognize a vocabulary of 100 words. The vocabulary was derived from example CG835 Worklists provided by inspectors. Only 83 words were generated from these lists. Much larger vocabularies would be needed for an operational marine inspection voice capability. The contractor was given two options for accomplishing this task.

Figure 8. Equivalent MPIU Pen-Controlled Barge Dry-dock Examination Hull Screens



Option 1 - The contractor shall overlay the voice recognition capability with the existing element of the Barge Inspection MPIU program. The voice recognizer would be required to activate the graphical user interfaces (GUIs) in the MPIU Visual Basic program as if the marine inspector were driving the software with the mouse. This effort would require some level of software modifications to the Visual Basic source code.

Option 2 - The contractor shall develop an independent program that would emulate the Barge Inspection Book GUIs that are used. An interface would need to be developed to modify the INSP.DAT file in the MPIU directory. The INSP.DAT file is an ASCII file that contains a record of which GUIs were selected and any associated comments.

Additionally, the contractor was required to perform a mock examination of a real barge at MIONY.

The contractor purchased a Verbex Voice Systems VATSL Recognizer board and installed it in a Coast Guard portable computer provided as Government Furnished Equipment (GFE). Custom speechware written in Borlan C++ was developed to accomplish the objectives in Option 2. The developed speechware provided:

- voice input of structural conditions for 12 barge structural components
- a computer voice vocabulary
- various convenient voice controls

The voice controls included:

quit	⇔	exists program
please repeat	⇔	repeats last feedback
freeze	⇔	makes recognizer deaf
listen	⇔	restores recognizer recognition
review conditions	⇔	summarizes condition inputs
review comments	⇔	review comments about structure type

4.2 Voice Recognition Technology Demonstration at MIONY

An equipment overview of gear used in the technology demonstration is shown in Appendix A. Appendix A contains a detailed contractor letter report on this effort.

4.3 MIONY Conclusions/Recommendations

The inspectors felt that there would be a definite time savings and improved safety using a voice recognition capability with an effective user interface. The inspectors were asked if the system would detract them during an inspection thereby increasing the chances of missing a problem or not be as safety conscious. They felt that this would not be

distracting at all and would be better because neither a portable computer or paper notebook would be needed. The inspectors expressed that this approach could be applied to any vessel inspection and that a future voice capability should be expanded from structural to other inspection categories such as lifesaving equipment.

Although the software side of this demonstrated potential there are some technical hurdles that must be addressed with regards to the hardware. Two aspects of the voice communications system require improvement. They are:

- the modulation/demodulation system

- packaging of the microphone/earphone/transceiver/battery

A 900 MHz Telenexus transceiver was used in the technology demonstration. It used direct sequence spectrum spreading digital modulation. An all-steel barge with many reflecting surfaces provides opportunities for multipath propagation. It was later determined that direct sequence spectrum spreading is susceptible to multipath cancellation which explained the intermittent communication fade-outs between the portable computer on deck and the inspector walking inside the tanks. A portable phone that employs frequency hopping was tested in this environment and found to deal with the multipath propagation problems effectively.

Although the "ear-muff" style microphones used were agreeable with the inspectors they suggested that other forms of microphones (bone-conduction or throat) and ear phones (hearing aid style) be investigated to improve signal to noise over shipyard background noise.

This voice recognition technology demonstration has not conclusively demonstrated that Coast Guard marine inspectors can more effectively collect inspection data or complete their tasks more accurately. However, it has demonstrated that it has potential and the prospect for its future consideration and development into an MPIU architecture should be kept open. For the present, any future MPIU requirements should include:

- the ability to maneuver with a mouse or pen be duplicated by keystrokes so that direct voice control could be employed

- have a file storage structure that can be modified by the adaptation of an independent voice inspection module

The application of human factor design for a truly effective user interface (UI) must also be addressed in the future. For a MPIU voice recognition system to be accepted, the UI would have to address many fundamental issues such as:

- striking a balance for easily distinguished words with a users requirement for easily remembered commands

- user requirements for appropriate feedback from the computer

- the UI leading speech to decrease the opportunities of users saying unexpected words not in the vocabulary

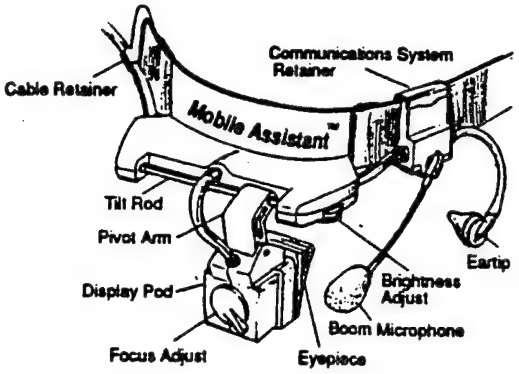
4.4 Port Demo Evaluation of Rockwell's Trekker System

In October of 1995, the R&D Center received the Trekker Mobile Information System on consignment from Rockwell Defense Electronics. The Trekker was configured with demonstration capabilities including the ability to launch the MPIU software by voice activation from Windows and to make voice queries of the SPINDRIFT reference library.

The Trekker system was evaluated because it represents state-of-the-art in mobile computer inspection. The Trekker is an interactive, voice-activated, belt-worn portable computer. Inspection data is collected via a head mounted VGA display, boom-mounted microphone, and speaker. The system consists of a monocular head-mounted display which allows an individual to perform tasks in an interactive environment while simultaneously viewing computer generated data. During the consignment period the system was worn as a headband but it could have been integrated with a hard hat. The monocular display provides a viewing image comparable to a 14 inch monitor perceived at 18 inches. The system provided on consignment was a 80486 with a 50 MHz processor with 4 MB of RAM and a 209 MB hard drive. A belt worn battery pack consisted of eight lithium ion cells which when fully charged would provide four hours of operation. As in most computer platforms, this system is upgradable to 32 MB of RAM and 540 MB hard drive. Figure 9 illustrates the Trekker system. These illustrations are from Rockwell's User's Manual.

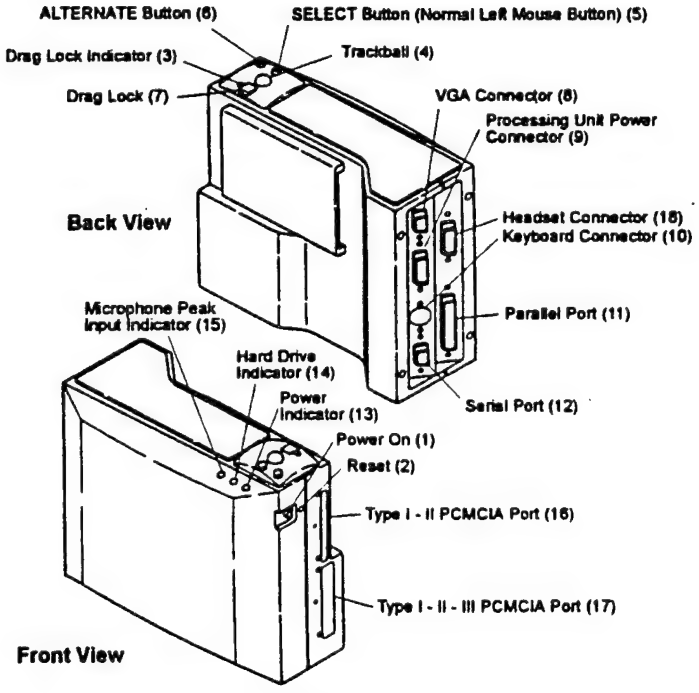
The resident voice communications software on the Trekker is commercially available from Listen for Windows™ by Verbex. This software allows the user to control Microsoft Windows™ applications by voice commands and goes so far as to claim to recognize conversational speech. It accomplishes this through Speech Interfaces and Voice Libraries.

Figure 9. Trekker Portable Computer System

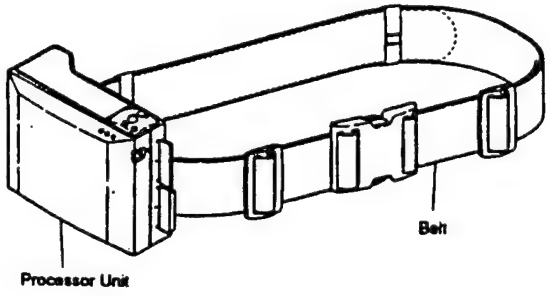


Mobile Assistant™ Headset

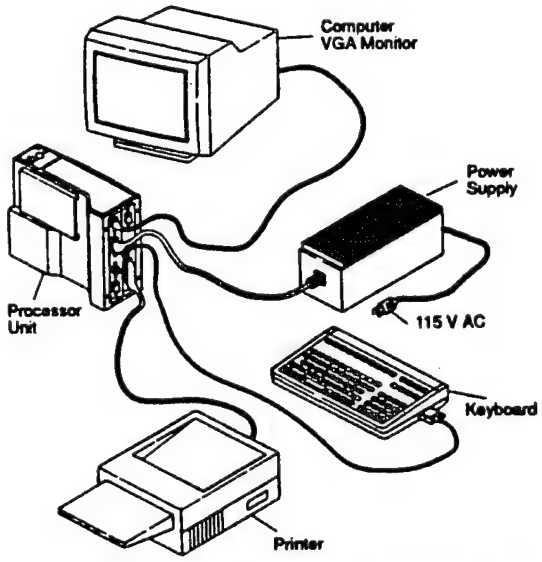
Correct Microphone Positioning



ROTATED 180 DEGREES



Processing Unit



Cabling System for Desktop Use

The Speech Interface consists of a group of command groups that have associated responses for specific commands. Essentially, when the voice recognizer hears you speak a command it compares the sound it heard with patterns stored in the Voice Library. The software is based on independent speech recognition which means that a cross section of American English speakers were sampled. Improved recognition is possible by indicating what sex the user is or through training the computer to recognize the user's unique speech patterns. The Listen program samples your voice and stores the patterns in unique Voice Library files. The program makes it easy to learn what voice commands are available to the user by including a dialog box or window overlay of available voice commands for the application running.

The voice control software required a couple of days of practice in addition to creating user-unique Voice Libraries, but it was apparent that an inspector could become proficient in a short time. A example script of maneuvering around in the Trekker system is provided below to illustrate how voice control could be exercised over the MPIU program.

Sample Script

SHOW WINDOW MENU
MOVE DOWN 5
(location of MPIU Program)
MOVE LEFT (or right) 1
SELECT ITEM
STOP LISTENING
(inspector makes a selection of an inspection file and maneuvers around using the trackball)
ACTIVATE LISTENING
(used when inspector wants to exercise voice control over program)
o
o
o
(inspector maneuvers around MPIU program)
o
o
o
SWITCH TO SPINDRIFT
(inspector switches to reference library from MPIU program)
SHOW SEARCH MENU
QUERY FOR
(due to the limited interface developed the inspector had to manually enter queries)
APPLY TO ALL
(searches reference library and displays hits)
o
o
o
SWITCH TO MPIU
(inspector can switch back to MPIU main program using voice)

The software was considered usable but would require a carefully designed marine inspector user-interface. The weak link in the system was the hardware. The head-set was uncomfortable and the belt worn battery pack and processor would limit an inspector's mobility in tight spaces. Although the Trekker was not tested in any merchant vessel spaces, it was the consensus that the present Trekker hardware configuration would be less portable than carrying a mobile pen-based computer.

The Trekker concept has potential features for a more efficient future MPIU system. The system could be improved by; 1) reducing the weight, 2) relocating the power supply and processor on the body, and 3) the introduction of a video image on the inside of inspector safety glasses which is always going to be an integral part of his personal gear.

5 MPIU Field Evaluation at MIONY

A technology demonstration similar to the Phase 2 field evaluation at MSO New Orleans was conducted from 20 October 1995 through 30 January 1996 at MIO New York. The R&D Center and Patriot Systems contractor provided a one-day training session on 19 October 1995. The objective of the technology demonstration in New York was to collect feedback on the MPIU concept and to collect specific feedback on the software and hardware employed. During this time frame, there was a lack of tankships in port available for inspection. Therefore, the MPIU Tankship program was not used as much as the Barge program. Since the T-Boat program was only partially complete it was not tested much. The R&D Center conducted a debrief on 30 January 1996 with seven inspectors who used the system. The Coast Guard Headquarter's sponsor G-MCO and G-MIR program manager were also present.

5.1 MPIU Hardware Overview

The hardware provided to MIONY in this demonstration came from the CGHQ sponsor (G-MCO) and from the R&D Center. The project sponsor permanently transferred the following gear to the unit:

- several IBM Thinkpad 360PE notebook computers with IBM Thinkpad keyboards, power systems, AC adapters, fax/modem PCMCIAs
- several IBM Thinkpads 730T pen-based portable computers
- several IBM Thinkpad docking stations
- several CD-ROM drives
- color HP Deskjet 320 Printers with accessories
- several Logitech digital cameras

The Compaq Concerto pen-based computer was the original choice for this test period but Compaq withdrew from the pen computer market before several units could be bought. The R&D Center loaned and permanently transferred the following gear:

- Compaq Concerto pen-based computer
- TI 4000 Travelmate laptop computer
- Two Telepad pen-based computers
- Apple Quicktake & Dycam color digital cameras

Present Coast Guard computer procurement procedures and restrictions made it difficult to acquire state-of-the-art computer technology for this effort. The computers used for this effort are representative of technology about a year old. Subsequently, no environmentally hardened pen-based systems, that are now available on the market, were used as test platforms. Presently, there are a number of lightweight, weather-proof portable notebooks as well as robust pen-computers on the market.

5.2 MPIU Hardware Feedback

Some of the inspectors indicated that the software was on the right track but that more focus should be placed on the hardware first. One of the inspectors felt that a portable computer the size of an 840 booklet (3"x 5") was needed. Although, personal digital assistants (PDAs) exist that are in this size range, they do not have the computing power of a pen computer or notebook. After more discussion it was determined that the inspectors did not want to trade off a fast response time and the ability to search large reference databases quickly for a very small portable computer. Most agreed that the small screen on a PDA would be too small and make it more difficult to take advantage of computer capabilities.

Only about half the group used the pen. The IBM 730-T pen computers arrived late in the demonstration period and were not used much. Inspectors felt that the pen was a good feature but not in lieu of the keyboard. The electronic pen was essential for drawing sketches and made maneuvering through the MPIU program quicker in many instances. The electronic eraser on the pen was a feature that should be incorporated in the final system. Almost all of the inspectors used the IBM Thinkpads. The Telepads saw little use and the Compaq Concerto had been loaned out to another unit.

It was felt that the computer screens did not have to be color for on-site field use but did have to be backlit in dark tank spaces. A black and white system would cost less than a color system. The inspectors expressed that they would need to dock the MPIU into color monitors back in the office to show captured images to others. Nobody expressed that they might need to view the quality of the image before saving it if a particularly small defect was found. For example, rust stains can't be discerned from black and white images.

No inspectors used the docking stations that came with the IBM computers. Generally, inspectors do not have sufficient desk space in the field to set up a complete bench top system with docking station. Inspectors cited another reason for not having used the docking station was their reluctance to perform their work twice, i.e., they would use the system if it was complete, that is, linked to MSIS and electronic mail.

Inspectors indicated that a color printer was not required in the field. Inspection certificates and worklists did not require color printing in the field. However, a color printer would be needed back in the main office.

The inspectors were pleased with the digital cameras but felt that they could still be smaller. The Logitech cameras were considered more portable than the Apple Quicktakes. Generally, the inspectors did not have any difficulties with the camera software and could easily import into other Windows applications. A strong need was expressed for having the ability to immediately view the image in the field after a picture was taken. This would eliminate the possibility of taking several bad pictures that would necessitate a return trip to the vessel. New cameras in the market have built in viewers to view the picture taken without the assistance of a computer. The close-up capabilities of the digital cameras were not considered very good and a minimum of one foot of exceptional quality close-ups were cited because inspectors often need to document small deficiencies such as hairline cracks.

In the MIONY office many of the inspectors operate out of their government vehicles when going out to the field. They felt that it was important to have the vehicles equipped with car adapters to fully charge cameras and portable computers enroute to a shipyard. They would prefer to have cameras that would accept both rechargeable and regular batteries which provides a little more flexibility in the field. The MIONY field detachments did not have Coast Guard Standard Workstations (CGSWIIs) available to them on-site unlike some other MSOs which might have a CGSWII set up in a field office. The MIONY inspectors generally all pass through the MIO building on their way to their temporary offices or inspections each day. This allows them access to the office's central filing system and MSIS terminals. Therefore, the inspectors are presently tied to always returning to the office to enter or retrieve MSIS data. In some instances facsimiles may be exchanged between the MIO and the field.

The inspectors were asked what kind of carrying cases would be needed. They did not want to use anything resembling a briefcase. Anything that allowed them to be hands free would work with a minimum requirement of having a shoulder strap integrated with the gear. Presently, inspectors are issued backpacks and would likely use these for carrying the MPIU gear until a better arrangement came about.

In this technology demonstration, there was no designated space that the inspectors could pick gear up, i.e., fully charged cameras, computers, etc. Generally, gear was kept in the Training Officer's office and other secure spaces. A better arrangement is needed that might include a dedicated small MPIU equipment locker with a rack of plug-in outlets.

Many inspectors felt that the fact that they might break a $3K piece of gear influenced whether or not they would bring the computer in certain spaces. Presently, they would restrict use of the MPIU to instances where they would have access to a clean environment with an office or table.

5.3 MPIU Software Overview

The revised MPIU software retained many of the good features from the first version developed by MAR, Inc. However, in addition to adding capabilities identified in Phase 2 field evaluations, this version of the program has taken advantage of the look and feel of the paper-based system which provides an important initial feeling of familiarity for new inspector users. This approach was thought to provide the inspector the ability to instinctually use the program compared to the first iteration which had restructured the book features. The following discussion only glosses over some of the MPIU software features. Additional information can be obtained from the MPIU User's Manual in Reference (5). The inspection manager is the initial screen that is displayed which requires the inspector to initiate the type of inspection being performed. Figure 10 illustrates this screen. Under the 'File' menu the inspector has the option of loading a PIP file from MSIS, printing of certain certificates in the field, e.g., COIs or IOPPs, or configuring the printing of custom reports based on MPIU field data.

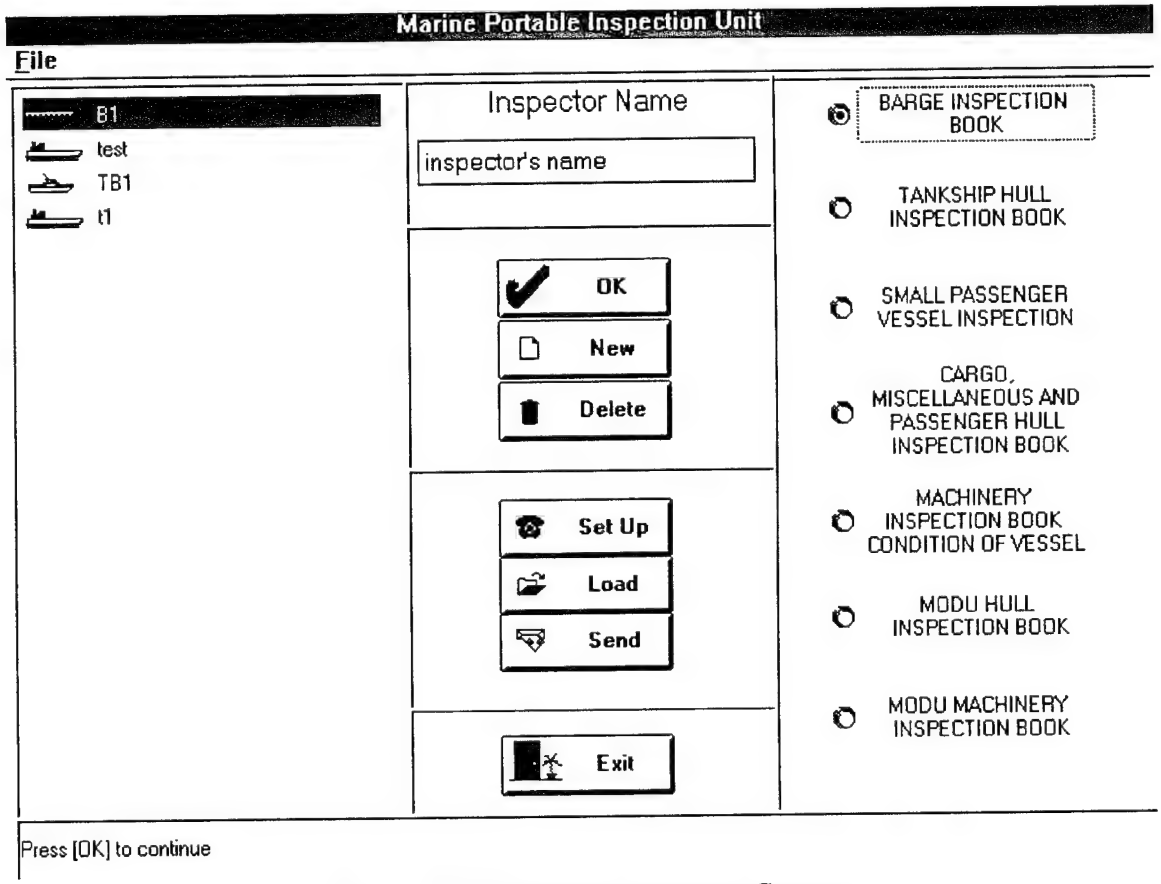


Figure 10. Inspection Manager Screen

The screen in Figure 10 provides the capabilities to load a new inspection, open an existing inspection, load or send inspection files via modem or direct communications, or delete inspections. Many of the MPIU screens have the look of a binder or folder similar

to the layout of the paper booklets. This is illustrated in Figure 11. Negotiating through the forms requires a click of the mouse or pen stylus anywhere on the page except for data entry fields.

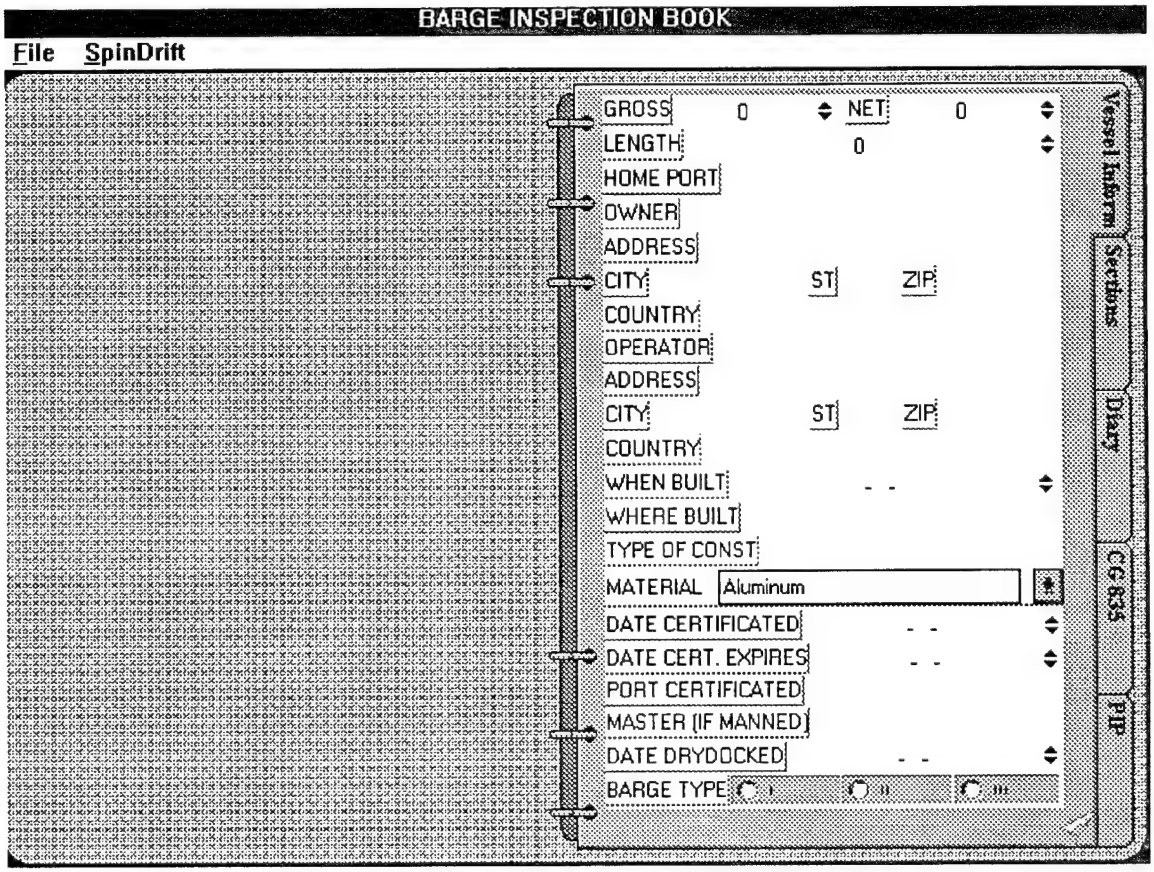


Figure 11. Major Sections of MPIU Program

The main tabs represent the major divisions that make up the MPIU. Figure 12 illustrates a typical Barge Inspection screen. This is where most of the inspection data is captured. At any point, either a deficiency can be logged or a electronic picture can be integrated to describe a problem. Digital pictures or templates of details can be integrated in a vessel inspection from remote directories or directly off a digital camera. The memory joggers that inspectors rely upon from time to time can be linked directly to the MPIU reference library. In Figure 12, *sea painter* is highlighted and underlined. The inspector can click this with the mouse or if working off a pen tablet use the electronic pen. Figure 13 illustrates the results of this action. The reference library developed for this demonstration called Spindrift allows the inspector to view all the hits (applicable references) or conduct customized searches using a single key word or a variety of combinations of keywords to track down information he needs in the field.

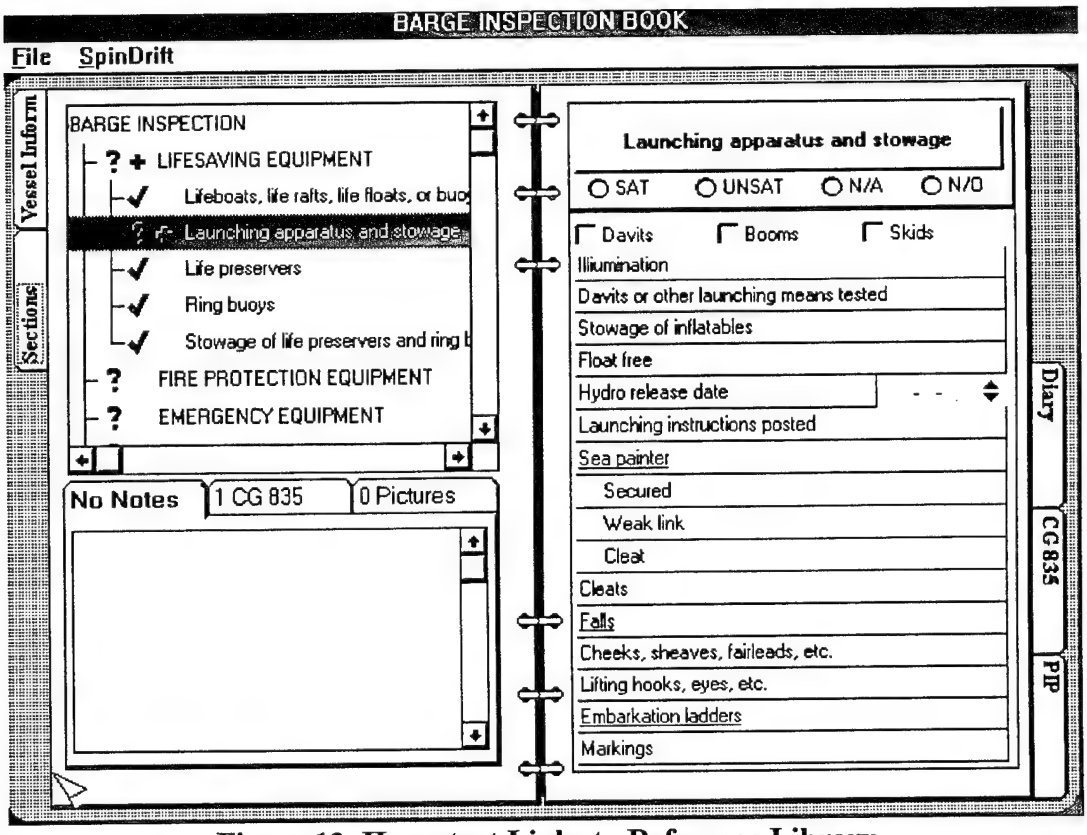


Figure 12. Hypertext Links to Reference Library

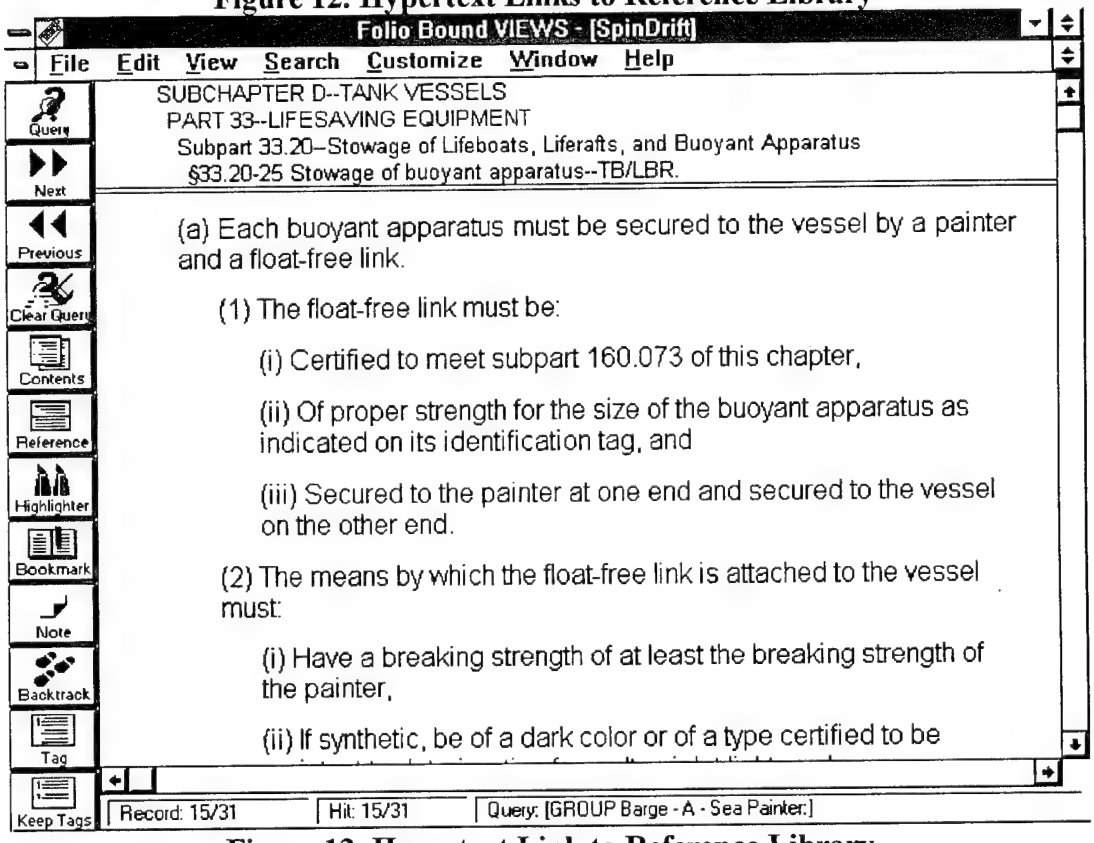


Figure 13. Hypertext Link to Reference Library

Presently, the Spindrift library contains the following:

- U.S. Coast Guard Marine Safety Manual
- Rules for Building and Classing Steel Vessels 1991 (Selected Parts)
- 33 CFR Navigation and Navigable Water
- 46 CFR Shipping
- 49 CFR Transportation
- NVICs
- Joint Federal Travel Regulations

The Reports section illustrated in Figure 14 provides a simple field level database for tracking the deficiencies recorded in the MPIU program. It allows the user to generate custom reports using all of the inspection data at his disposal. The inspector can further sort the data by viewing all deficiencies or just open deficiencies on all class of vessels or a specific vessel. The inspector can also retrieve a Certificate History File, Case Report, or Deficiency History. The fields on the right of the screen of Figure 14 provides the ability to further limit the reporting based on very specific information such as location, type, cause, etc.

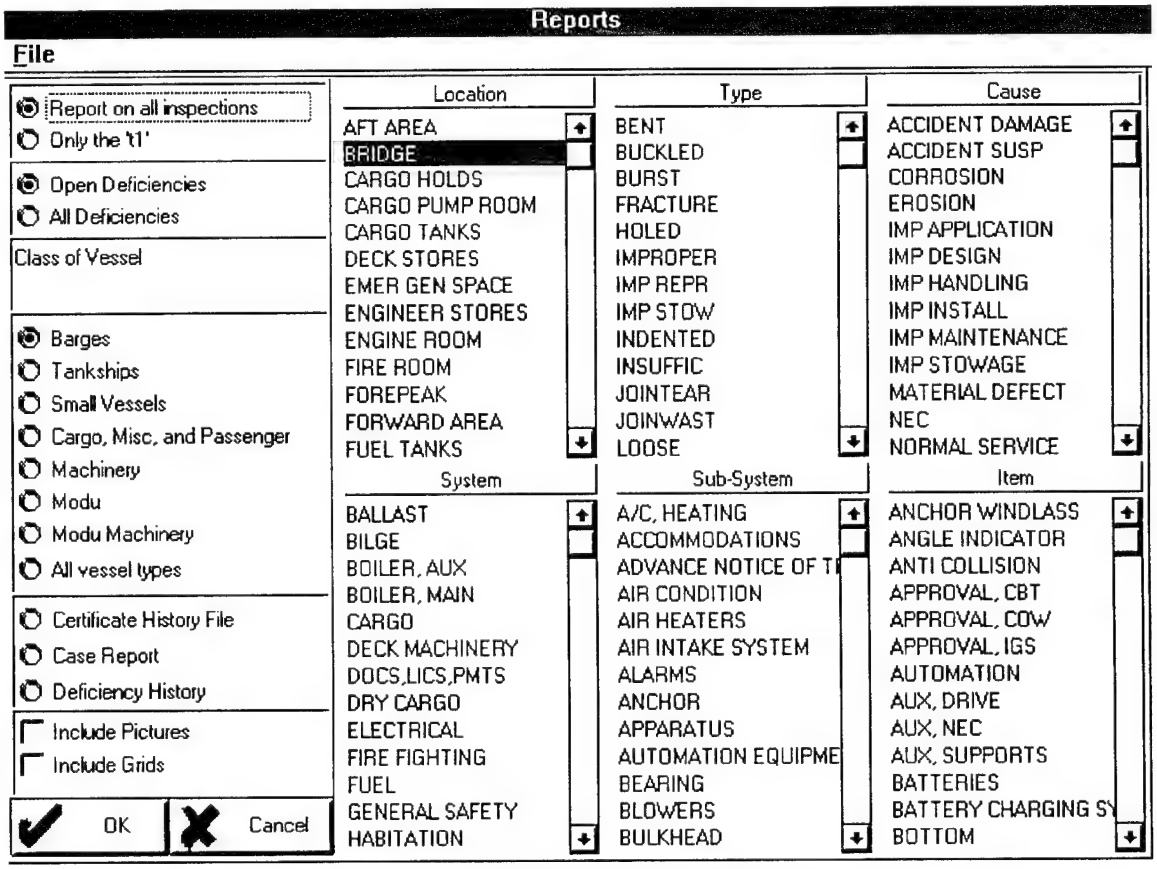


Figure 14. MPIU Reporting Options

5.4 MPIU Software Feedback

It was asked how the MPIU concept might affect the Coast Guard business of marine inspection. The inspectors felt that it wouldn't change the way business was done but would make the Coast Guard functions more efficient by speeding up data entry into MSIS and giving the boat owner timely feedback in terms of COIs, etc. If inspectors could get the inspection data into MSIS quickly and get a quick turn around on validation they envisioned a response time of one week to issue a COI to a boat owner compared to several months in some instances. They felt that office procedures could be streamlined if they did not have to always go to the office to work with MSIS with an MPIU capability on-site. They felt a significant time savings could be achieved by combining the 840 book data collection with the MSIS data entry aspect.

It was asked, if given the choice, would they be willing to spend more time in the field capturing data electronically to eliminate time spent interacting with MSIS. Generally, the answer was yes. One reason cited was because of limited MSIS terminal availability, in the context of the present procedures, they could do what they needed to do from the MPIU and not wait in line for a terminal. A concern was expressed that taking much more time to electronically capture data in the field might delay the boat owner and the inspection of other vessels. If the delay was significant this might translate into lost business to the boat owner if he were to delay operations because of the Coast Guard.

It was asked if MIONY inspectors enter MSIS data themselves. Their response indicated that they are performing more and more data entry themselves to help speed up the process. This is being done even though they have a dedicated data entry staff of three persons. Inspectors often print out copies of MSIS product sets and write in what they want changed and give it to the data entry persons. This practice is considered very inefficient by the marine inspectors. However, there are some other functions of the data entry staff that include the sending out of notifications such as overdue CG835s and sending out COIs.

Inspectors felt that the MPIU with its linked electronic sketches, digital pictures, and deficiency lists provided a better flavor of the inspection compared to present inspection information that might be exchanged from one port to another or retrieved from MSIS. For example, the inspection of a dry-docked vessel might result in a 100 item worklist that doesn't necessarily go into a permanent file. To see what was done at a different port would provide advantageous insight into that particular vessel.

It was suggested that the maintenance responsibilities of the MPIU hardware and software in an office the size of MIONY could be done as a permanent collateral duty. The resident system manager is presently overwhelmed with the CGSWs and could not be expected to take on more responsibility. This might change with the change-over to the DOS-based CGSWIIIs.

Although the MPIU program had the ability to print out several certificates, after having been filled out automatically with the MPIU program, this feature was not experimented with. This was because they needed to have the Commanding Officer's (CO's) signature on file. Armed with the CO's signature and the authority to print COIs along with other forms in the field the MPIU program would greatly improve efficiency in this regard.

The inspectors indicated that some automated features for tracking the transmission and receipt of MPIU data between MPIU units and MSIS would have some benefit for accounting purposes and that an electronic return receipt would probably be sufficient.

Although there are software tools that train the pen computer to recognize a person's unique handwriting, most inspectors did not even run through it. Generally, the inspectors felt that the character recognition needed improvement and that it wasn't practical for writing more than a sentence or two.

It was asked if the inspectors might prefer a compartmental-based strategy rather than a functionally-based strategy for the MPIU program. It was felt that this option should be explored further, even though it represents more complex programming, since the CG840 book format may not necessarily be the best format to model after.

Since inspectors deal with unclassified information that could easily be obtained through the Freedom of Information Act they did not see a need for any elaborate security measures, such as encryption or physical software keys. It was suggested that a keystroke in the MPIU software would protect the integrity of the inspection file including the 840 book information and diary. For example, the CID could not accidentally backspace over the inspector's work. Additionally, a feature should be included to permit the use of strikeout text over completed write-protected inspection files.

Nearly all of the inspectors were pleased with the Spindrift reference library. One inspector expressed that he still preferred the manual method. Further discussion revealed that they did not take advantage of all of the features in Spindrift such as the electronic bookmarks or the ability to customize and link searches from an MPIU memory jogger. This represents a shortfall in the training that was done in October. They all agreed that the ability to customize the linking of memory joggers in the inspection forms to the Spindrift reference library was important. They indicated that Spindrift needed to have all of the international regulations on it and recommended the following be added; Alternate Compliance Program (ACP) Supplement, MARPOL, and Standards of Training Certification and Watch Keeping (STCW).

The inspectors felt that the lack of an MPIU-MSIS interface made it more difficult to fairly evaluate the MPIU concept and potential time saved and considered the MPIU, without an interface, a cumbersome electronic 840 booklet with neat features. Several times in the course of the discussions inspectors expressed that they wanted one-stop data collection and that the data collected with the future MPIU should automate any coding or

file preparation required for MSIS. The inspectors felt that the digital images captured with the MPIU should be retained in the new marine safety database.

The one significant addition inspectors want to see in the MPIU program itself is the ability to print out worklists. The MPIU should configure an inspection item as a worklist item and if it couldn't be resolved, automatically converted to an 835.

When asked what they thought was the next logical step to this study the consensus was that a prototype interface with MSIS needed development. Otherwise, there would be no need to go any further in this effort because they have only been given half a tool with limited benefit.

5.5 MIONY Conclusions/Recommendations

Although MIONY inspectors were provided with some initial training on the system they did not test out all of the features provided in both the hardware and software, for example, they did not use the MPIU to MPIU file modem transfer programs or print out MPIU generated CG-854, CG-840S-1 (and-2), or CG-5352 certificates. This was consistent with the technology demonstration at MSO New Orleans where in both cases inspectors weren't provided with a fully functional system to assist in their inspection duties. The MPIU was considered a sophisticated 840 book with reference capabilities without an interface with MSIS. The test periods were only a couple of months but longer test periods would probably not have revealed much more.

Inspectors agreed that employing a fully functional MPIU capability would not change the way business is done but would make Coast Guard inspection functions more efficient for both the marine inspectors and boat owners waiting for inspection results. Inspectors generally set up the MPIU notebooks in temporary clean spaces on the ship and in the shipyard but all agreed that they wanted a more portable option of a pen-based capability for some inspections. It is anticipated that the use of a future fully functional MPIU system with environmentally robust portable computer would become second nature to the inspector over time and would be used in more situations than presently predicted.

The MPIU software needs the ability to configure worklists from MPIU inspection items that can be printed on-site. A compartmentally-based configuration should be investigated as an alternative configuration for capturing inspection data. Inspectors were pleased with the Spindrift reference library but recommended that it contain all international regulations as well.

The inspectors all felt that the next logical step in this study would be to develop a prototype interface with MSIS to fully test productivity gains that could be achieved with a portable MPIU capability.

6 Prospects for Coast Guard and Classification Society Interoperability

6.1 Classification Societies and Their Responsibilities

Classification societies have been in existence for over 300 years. The origin of today's societies can be traced back to the meetings of insurance underwriters at Edward Lloyd's coffee house in the City of London starting about 1691, the predecessor to the present Lloyd's Register. The society of Underwriters produced the first Register of Shipping in 1760. Underwriters employ their own surveyors to make periodic surveys and kept registers containing the particulars on the ships they insured. Classification societies arose in other countries to perform similar functions for their underwriters.

Over time, classification societies developed detailed rules to determine the proper class to assign ships. These rules are now very sophisticated. The International Maritime Organization (IMO) has promulgated detailed rules on all phases of ship safety except structural safety. In the structural safety area, IMO recognizes the role of classification societies. The IMO 1966 Load Line Convention requires that a ship must be of adequate strength before a Load Line Certificate is issued. The Convention further states that ships built and maintained in conformity with the requirements of a Classification Society recognized by a flag Administration may be considered to possess such strength. Every nation recognizes the rules of one or more Classification Societies as the guidelines for verifying adequate strength. The U.S. recognizes the rules of the American Bureau of Shipping for this purpose.

The major Classification Societies have banded together in a group called the International Association of Classification Societies (IACS). IACS promotes quality among its members and is a clearing house of information including interpretations of IMO and Flag Administration requirements. Current members of the IACS are: Det Norske Veritas, Germanischer Lloyd, the Korean Register, Lloyd's Register of Shipping, Nippon Kaiji Kyokai, Polski Rejester Statkow, Registro Italiano Navale, and the Register of Shipping (Russia). Hrvatski Register Brodova and the Indian Register of Shipping are associate members.

Classification Societies perform two major types of surveys; classification surveys and statutory surveys. Classification surveys are those required to acquire and maintain class under the rules of society. The requirements for these surveys are up to the classification society. Most of the Flag Administrations or Flag States, where a ship is registered, do not maintain extensive ship inspection organizations. The United States is an exception. Although, the recent promulgation of an alternate compliance program (ACP) in the U.S. is a step in this direction. The implications of ACP on the MPIU concept will be discussed later. Most Flag Administrations delegate their inspection/survey responsibilities to one or more Classification Societies. This is permitted under IMO Regulation 6 of the Annex to the International Convention for Safety of Life at Sea, 1974 (SOLAS). However, the administration is still responsible for the completeness and efficiency of the inspection. Surveys conducted to determine compliance with IMO regulations are called statutory

surveys. These statutory surveys may also include additional requirements imposed by the Flag Administration.

Statutory Surveys:

Owners pay Classification Societies to conduct statutory surveys, not the Flag Administration. The owners pay because IMO requires that a ship have certain certificates before it can engage in international trade. These include:

- Cargo Ship Safety Construction Certificate or Passenger Ship Safety Certificate
- International Load Line Certificate
- Cargo Ship Safety Radio Certificate
- Cargo Ship Safety Equipment Certificate
- MARPOL Certificates

Classification Societies have supplemental checkoff lists that they use when performing statutory surveys before providing any of the above certificates in the name of the Flag Administration. These checkoff lists were compared with the U.S. Coast Guard's inspection requirements to generate Table 2. This table demonstrates that the Classification Societies inspect nearly the same areas as does the Coast Guard during statutory surveys. Classification Societies routinely add additional Flag State requirements

Table 2. Comparison of Classification Society and Coast Guard Inspections

US Coast Guard Inspection Category	American Bureau of Shipping	Lloyds Register
Vessel Information	some items	some items
Certification and Inspection Data	some items	some items
Stability	similar requirements	some items
Hull, Decks, Fittings, and Watertight Integrity	similar requirements	similar requirements
Structural Inspection and Gauging	similar requirements	similar requirements
Lifesaving Equipment	similar requirements	similar requirements
Fire Protection Equipment	similar requirements	similar requirements
Emergency Equipment	similar requirements	similar requirements
Cargo Handling, Ballasting, and Bunkering	similar requirements	similar requirements
Cargo Transfer System	similar requirements	similar requirements
Pollution Prevention	similar requirements	similar requirements
Inert Gas Systems	similar requirements	similar requirements
Ventilation	similar requirements	similar requirements
Navigation Equipment	similar requirements	similar requirements
Ground Tackle	similar requirements	similar requirements
Accommodations and Other Spaces	not applicable	not applicable
Emergency Drills	similar requirements	similar requirements
Forms, Notices, Publications, and Records	some items	some items
Hull Markings, Draft Marks, and Load Line	similar requirements	similar requirements
Officer Competency	not applicable	not applicable
Personnel Safety	similar requirements	similar requirements
Hazardous Conditions	similar requirements	similar requirements
Propulsion Machinery and Controls	similar requirements	similar requirements
Boilers and Pressure Vessels	similar requirements	similar requirements
Auxiliary Machinery	similar requirements	similar requirements
Sea Chests and Valves	similar requirements	similar requirements
Electrical System	similar requirements	similar requirements
Steering Gear	similar requirements	similar requirements
Rudders	similar requirements	similar requirements
Propellers	similar requirements	similar requirements
Tail Shafts	similar requirements	similar requirements

to their inspection checkoff lists. The differences between the classification society inspections and the Coast Guard inspections could be easily handled in this way if the Coast Guard were to authorize a Classification Society to perform statutory surveys for the U.S.

Classification Society Information:

The principal purpose of surveys by Classification Societies remains the verification of ship safety so that owners can purchase insurance at a reasonable rate. Without this insurance they could not get cargoes. The owners or their agents pay the cost of all plan review and surveys done for classification and the results of these are the property of the owners, not the Classification Society. Any request for classification survey information is sent to the owner who can release the information or not. The Classification Societies all stated that they would not reveal classification survey information without the owner's

permission to anyone, including Flag and Port states. Both DNV and Lloyd's Register stated that an IMO resolution requiring release of information would have to be passed and ratified before Classification Societies would routinely release classification information to Flag and Port states.

A more confused situation exists in the case of statutory surveys. Although the owners pay for these surveys, the classification society is granted the right to issue certificates by the Flag Administration. The survey still belongs to the owner but the Flag Administration has a right to the data also. The people interviewed were not clear on their companies policies with regard to revealing statutory survey information to Flag States. In most cases the request is passed to the owner who always grants the classification society permission to give the information to the Flag Administration. The Flag Administration may release the information to Port States at its discretion. All the classification societies stated that they would not pass statutory survey information to Port States directly. None of the classification societies sanction release of information from its surveyors directly to Coast Guard inspectors. However, such sharing of data does take place.

Classification societies are willing to release general data about ships and their owners. In fact, publications such as those by Lloyd's Register have done this for centuries. This information does not include such information as due dates for statutory inspections of any deficiency information. Lloyd's Register currently has a database on shipping called SEA DATA that is available on a fee basis to anyone who wishes to subscribe. There is a possibility that this database will be expanded in the near future to include due dates for statutory surveys, but not deficiency information. There is less information in this database than in the Port State Information Exchange (PSIX) offered by the U.S. Coast Guard.

An initiative is underway through IMO and IACS to provide SEA DATA type data from all member classification societies. The details on how this will be done and what information will be provided have yet to be resolved. This could take the form of a direct computer hookup, but is more likely to be an email type arrangement with requests for information being passed to individual societies who would then respond with the desired information. This is more likely because of the differences in hardware and software each classification society uses for its main database.

Computer Mainframes and Software:

The classification societies use a variety of hardware and software to support their main databases. Lloyd's Register uses a Hewlett-Packard mainframe computer with a software system called NVS/XA. However, they are strongly considering a switch to Oracle based software. Lloyd's surveyors can access the database from field offices and enter survey data into the database. The American Bureau of Shipping has an IBM mainframe running a DB2 compatible program called Sapiens. This is a SQL compatible program. All survey reports are sent in paper format to ABS in Houston for input to the database. Det Norske Veritas uses a mainframe database called Sprint. Field offices can access this database and

update it directly. In the future, DNV plans to replace the Sprint software with a SQL server. The software and hardware for this system is under development at the present time. A system based on Sybase software is a good possibility.

Field Office Computers and Software:

One common thread among the classification societies interviewed is that they all have standardized on Microsoft Windows software and IBM compatible PCs in their field offices. The American Bureau of Shipping uses PC Simware software to access data from their mainframe computer in Houston. Det Norske Veritas uses PC Anywhere software for the same purpose. Lloyd's representatives did not know the name of the software they use for this purpose. Det Norske Veritas has standardized on Microsoft Visual Basic as their development tool for new applications. ABS tries to use non-developmental software whenever possible. ABS is considering groupware such as Microsoft Office software to route items for internal signatures. Such groupware provides signoff control of documents over a local area network.

Computer Use by Surveyors:

A few years ago, ABS conducted a field trial using pen computers. This was referred to as the Portable Computer Pilot Project (PCPP) and took place in 1992 through 1993. ABS set up three base stations (in Houston, New Orleans, and Mobile) to support surveys of LASH barges. The ABS final report considered the project a success in terms of report turn-around-time and felt that the use of the pen-based portable computers was a good choice. The pen computers ease of operation made their use less intimidating to the surveyors. Although, at this point in time, ABS considered the character recognition of the pen operating system as having only minor advantages. This trial took place during the early days of pen computer development when handwriting recognition was very slow due to processor speed, storage capacity was much less than today, and the trial did not link the data collected in the field to the central database. Thus, their surveyors still had to write out the data by hand and submit the survey forms to the Houston office for entry into the mainframe database.

Computer use is not widespread among surveyors, many of whom have been in the business a long time, but Lloyd's is probably ahead of others in putting laptop computers into the hands of surveyors. Det Norske Veritas is seriously considering the use of pen or laptop computers in the field but has yet to implement a system. Lloyd's plans in the near future to allow inspectors to hook up to the mainframe database directly from the ship being inspected and enter survey results directly. They can do this now from field offices. This should speed the processing of survey data a great deal. Lloyd's clearly places the responsibility for conducting the survey directly on their surveyors.

6.2 Prospects for Interoperability

At present the Coast Guard should not promulgate any generic standards on how marine inspection data is electronically collected or formatted. This is the responsibility of individual classification societies to best meet their needs.Classification societies are under no obligation to share this data with the Coast Guard. The United States should continue to pursue agreements through international forums such as IMO rather than dictate policy.

Before much of the survey data can be shared, international agreement has to be reached on the rights of Flag States and Port States to this data. At present it belongs to the vessel owners. There can be no discussion on sharing data between Coast Guard inspectors and classification society surveyors until this matter is resolved. Thus, the issue of having a common format for data collection at the local level is moot at this time. It is recommended that the Coast Guard pursue agreement through IMO as to what data is shared.

Since IMO and IACS have begun work on sharing certain general ship information, it is recommended that the Coast Guard work with these organizations to have as much information as possible included in the accessible data. It appears that classification societies would be willing to release due dates for statutory surveys as well as general information such as is now found in Lloyd's Register. It is much less likely that they will release information on discrepancies found during their surveys.

The Coast Guard is going in the right direction by adopting IBM compatible field computers and Microsoft Windows software. This fits nicely with what classification societies have adopted and will permit sharing of data in the future should agreement be reached as discussed above. The Coast Guard should proceed with development of their own inspection system without trying to link it with classification society systems at this time.

6.3 Alternate Compliance Program (ACP) Implications on MPIU

Recently, an Alternate Compliance Program (ACP) was promulgated by the Coast Guard to minimize duplication of effort between the Coast Guard and Classification Societies without jeopardizing safety. Owners of certain U.S. flag vessels can elect to use the services of a designated Classification Society for vessel inspections. U.S. Coast Guard Certificates of Inspection (COIs) can be issued after a designated Classification Society certifies that the vessel complies with the International Convention for the Safety of Life at Sea, 1974 (SOLAS), classification rules, etc. The Coast Guard provides the oversight of the ACP participants through random checks, system audits, and performance tracking. At present, there is an ACP pilot program with the American Bureau of Shipping. Oversight procedures are described in Reference (4).

7 Conclusions and Recommendations

7.1 Summary of MPIU Phase 3 Findings

The observations of the test group at MIONY nearly mirror the observations of the MSO New Orleans marine inspectors in Phase 2. This is significant in that it validates the R&D study findings as being representative of marine inspectors generally as opposed to a specific group. In both field studies the most significant concern with regards to the execution of this study was the lack of an interface between the MPIU and MSIS which ultimately limited the usefulness of the MPIU to that of a sophisticated 840 book with on-line reference capabilities. The potential of a fully capable MPIU tool was easily recognized by all of the marine inspector participants in these technology demonstrations as being limitless. Generally, the MPIU hardware should consist of notebooks with portable printers that can be set up in temporary offices or spaces on a vessel to be inspected. Inspectors want the option of a portable pen-based computer to take with them on some inspections where both platforms have sufficient reference libraries of governing U.S. and international rules and regulations that eliminate the need to carry paper references. A functional description is provided as Appendix B. It provides a functional description of the hardware and software needed to implement a portable marine inspection capability. Its purpose is to serve as an initial basis for mutual understanding between user and developer for further MPIU studies, development, or implementation.

In this phase a number of significant new features were added to the MPIU system including a linked on-line reference library with commonly used rules and regulations, MIPIP to MPIU interface, simple deficiency database, MPIU to MPIU interface, color digital cameras, and field printable certificates. Although these features were discussed and considered as being important, inspectors did not fully explore all of them.

Some technical hurdles, e.g., deck-to-tank space communications in a shipyard environment or reduced hardware size for body worn systems, most be overcome before computer voice recognition technology can add any value to capturing inspection data in the field.

The Coast Guard should proceed with the development of their own IBM compatible field portable inspection system without trying to link it with classification society systems at this time. Presently, classification societies are willing to release due dates for statutory surveys as well as general information but are less likely to release information on discrepancies found during their surveys. In the future, with the advent of the new CGSWIIIs, there will be operation system compatibility with classification society computers but a common format for collecting specific data at the field level may not be feasible in the near future.

7.2 Recommendations for a Fully-Integrated Marine Inspection Office MPIU Pilot Study

It is recommended that a prototype two-way interface be developed between the MPIU and MSIS followed by a pilot study at MIONY. The R&D Center should prepare the file of specific data required for MSIS on the MPIU system. This would include any unique coding of data. Coast Guard Operations Systems Center (OSC) should import this file into the proper locations in MSIS. If possible, the prototype interface should be developed in a way that would not impact MSIS response times and perhaps reduce demand for CGSW time by sending MPIU inspection data during off peak usage. Even though MSIS will be replaced in a couple of years, having a prototype interface now would permit the study of time, resources, and new streamlined office procedures involved in the exchange of inspection data between portable MPIUs and MSN as it would relate to Coast Guard wide implementation.

With a fully functional MPIU system a pilot study should be conducted at MIONY. The pilot study should include an experimentation of new office procedures to improve efficiency and a long period comparison between a detachment with MPIUs and without to quantify gains that might be achieved and projected Coast Guard wide. This would represent a first step in a phased introduction of portable MPIU computers to the field. Another cost/benefit study and time saved analysis should be conducted, the results of which will reflect more accuracy than the limited R&D study. The pilot study should be jointly managed by G-MIR as the technical manager and G-MCO as the program sponsor. Coast Guard R&D Center involvement would transition with support in the development of the MPIU-MSIS interface.

7.3 Recommendations for Future Technology Demonstrations

It is recommended that the Coast Guard continue performing technology demonstrations in the field. Every year information technology makes advances and sometimes in unexpected directions that could yield significant benefits to the marine inspector. It is only through these technology demonstrations in the field that the Coast Guard can discover new tools that can compensate for reduced personnel and leaner budgets in the new streamlined Coast Guard. The following technology demonstrations are recommended:

- It was determined that portable computers, no matter how lightweight and compact they may become, would not be used in certain areas of the vessel where inspector's safety is of primary concern. Normal computer assisted inspection is not possible for some forms of inspection. The voice recognition technology demonstration revealed that there could be a time savings and improved safety associated with using a voice recognition capability with an effective user interface. The shortfall in the demonstration was the communications between the deck portable computer and inspector microphone in the tank space. Another technology demonstration should be done that would involve using a frequency hopping communication system with

alternative microphones such as bone-conduction or throat microphones to improve signal to noise over shipyard background noise.

- Develop a compartmentally-based MPIU program that would keep all of the deficiency entries necessary for a specific compartment or space on a vessel together. Automatic features should help the inspector initially customize the configuration that would then be stored semi-permanently as either a vessel or class specific program that would facilitate future inspections. A technology demonstration should address one inspection type such as a tankship and be tested after a fully functioning MPIU capability is in place.

Conduct a state-of-the-art survey of environmentally hardened portable computers on the market. A technology demonstration should involve selecting several best candidates and testing them with an inspection office that is employing portable computers. This evaluation would assess if the introduction of truly robust portable computers would see more use in the field than the more fragile systems discussed in this study.

8 References

(1) "Assessment of the Coast Guard Marine Safety, Security, and Environmental Protection (M) Program," Coast Guard Report No. CG-D-11-89, March 1990.

(2) "On-Site Marine Inspection Data Capture," Coast Guard Report No. CG-D-05-93, December 1992.

(3) "Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU)", Coast Guard Report No. CG-D-28-94, September 1994.

(4) Oversight of the U.S. Coast Guard's American Bureau of Shipping (ABS) Based Alternate Compliance Program, COMDINST 16711.17, 12 June 1995.

(5) User's Guide to MPIU - Marine Portable Inspection Unit.

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APPENDIX A

Voice Recognition Technology Demonstration Letter Report

This is the final letter report for the tasks described in the CG R&D Center's Statement of Work for The Marine Portable Inspection Unit (MPIU) Voice Recognition Technology Demonstration. The work was performed under ETC project 3423 which was awarded in response to the Coast Guard R&D Center's RFQ-006-95.

This report is divided into 3 parts:

1. Program Summary - which summarizes what transpired during the conduct of the program.

2. Conclusions - which summarizes what has been learned during the program.

3. Recommendations - which summarizes suggestions for moving the development process forward towards the goal of developing a Voice Activated Barge Inspection (VABI) system that will improve inspection efficiency and enhance safety.

PROGRAM SUMMARY

The MPIU program has developed a pen-based portable computer system that permits inspectors to make inspection entries by checking off the condition of structural components and inserting hand-written comments. A drawback of the system is that there are places on board a barge where carrying a computer and pen are a handicap to the inspector and a potential safety hazard.

The alternative explored in the VABI program was to substitute voice entry in place of pen-based entries and to substitute aural for visual feedback. The inspector would only have to wear a microphone/earphone headset and would have his hands and eyes free.

The program was modeled on voice controlled command and control and log-entry systems developed for the Navy. The pen-based computer system was based on a Windows display. The Coast Guard suggested two alternatives for implementing voice control:

1. Modify the Windows program to accept voice inputs
2. Have the voice control generate the same file programs as the Windows program.

ETC chose the second alternative because it did not involve modifying code generated by others.

The program was divided into the following phases:

1. Development of Speechware
2. Development of software
3. Propagation experiment
4. Communications equipment modification
5. System integration and test
6. Demonstration and training at Marine Inspection Office in New York (MIONY)
7. Field test aboard a barge on Staten Island
8. Report and demonstration at CGHQ in Washington DC
9. Final Letter Report generation

1. Development of speechware:

In order to develop the Voice Activated Barge Inspection (VABI) system it was necessary to create a number of recognizer related programs, collectively known as speechware. These programs included:

* grammars for log_in and inspection inputs
* scripts for training the recognition programs
* recognizer control programs
* voice feedback pre-recordings
* voice files unique to each potential user
* batch files to reduce or eliminate keyboard entries

These speechware programs were developed, tested and modified in response to CG inputs. Although there are both speaker-independent and speaker-dependent voice recognition systems, the speaker-dependent systems provide better recognition reliability and allow the users to customize the vocabulary and pronunciation. For this reason speaker-dependent voice files were generated and a training program for the generation of these files was prepared. The resulting speechware programs provided:

(1) Voice input of structural conditions for each of 12 structural components (i.e.; decks, bulkheads, floors, beams, connections, previous fracture repairs, longitudinals, examined for fractures, tank tops, frames, stiffeners, intercostals), with the condition classified as satisfactory, SAT, okay, unsatisfactory, UNSAT, deficient, not applicable or NA.

(2) Comments that were derived from a WORKLIST/CG-835 provided by MIONY inspectors. These comments were only samples of the type:

"reweld crack as marked in bay 9 port side"

Grammatical "structures" (groups of similar word types) were created to permit a large

number of combinations and permutations of the vocabulary of 83 words. Much larger vocabularies have been demonstrated on other programs.

(3) Controls that permit the inspector the following capabilities:

quit.....exits program
please repeat.....repeats last feedback
freeze.....makes recognizer deaf
listen.....restores recognizer recognition
review conditions.....summarizes condition inputs
review (structure type) comments.....reviews comments about structure type

The log-in portion of the speechware permitted the automatic downloading of each user's voice file upon recognition of the user's unique verbal password.

2. Development of Software:

A barge.exe program was generated to perform the following functions:

* Accept and translate recognizer inputs
* Generate a database file of inputs
* Sort inputs into the pen-based Windows program order
* Process requests for reviews
* Assemble and feedback reviews
* Generate "Insp.dat" and "Summary.dat" files for compatibility with the pen-based inspection system

The software was written in Borland C++. It consisted of over 2000 lines of code and commenting. The C++ program incorporates Code Base and uses DOS sorting to put entries into the Windows program structural categories order. Voice feedback was written into both the barge.exe program and into the speechware for the reviews and confirmations, respectively. Special sorting algorithms were programmed in order to generate the "Insp.dat" and "Summary.dat" files. These files can be loaded into the windows program and will generate the same graphics as if the entries had been made by the pen-based system.

3. Propagation experiment:

A test was conducted aboard a barge on Staten Island, on May 10th, to validate the use of the 900 MHz frequency band for communications from within a hold to a base station on deck. An AT&T portable digital telephone was used to conduct this experiment.

Lt. Bernholz of the MIONY took the portable phone (approximately 7 meters) down into the barge hold and walked to the furthest extremity (approximately 25 meters) where he conducted communications with the base station on the deck. The hatch opening was

approximately 1/2 meter. The base station was moved to several locations on the deck, from immediately above the hatch opening to locations on the deck laterally removed by as much as 10 meters. The phone was used in the intercom mode. Conversational speech between the deck and from within the tank of the barge was continuous and clear. The communications propagation experiment was considered successful.

4. Communications equipment modification:

The hardware for the VABI system is shown in figure 1. The recognizer (Verbex Voice Systems VATSL Recognizer board) was mounted in a Coast Guard supplied Compaq portable computer. The Radio Shack speaker was used only so that demonstration witnesses could hear what the inspector was hearing. Telenexus equipment was selected for communications. The equipment consisted of:

. remote transceiver
. spatial diversity combiner
. base station transceiver

The equipment was modified by Telenexus to interface with the computer-based recognizer and rented for a 90-day period to cover the test and demonstration phase.

5. System Integration and Test:

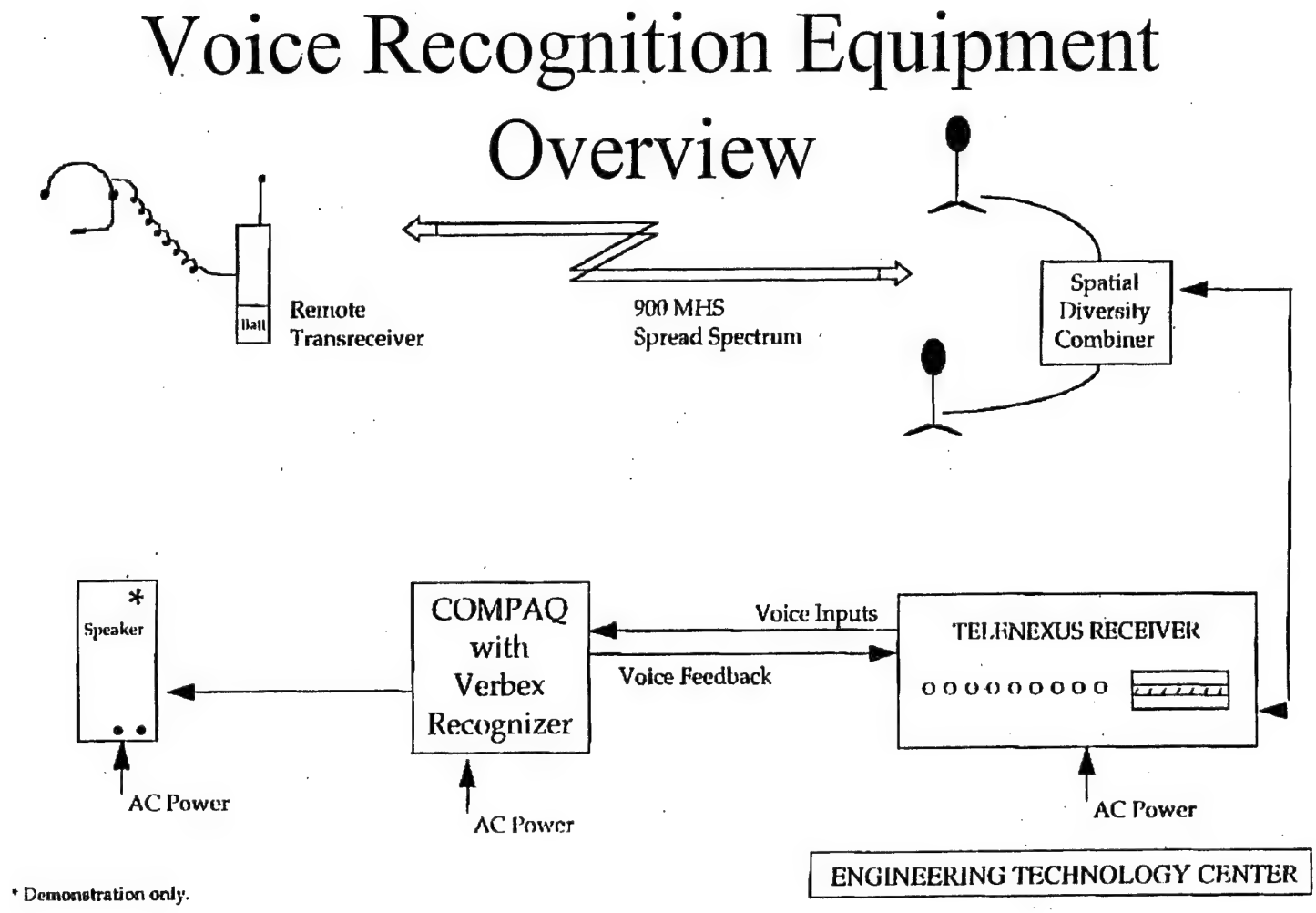
The Coast Guard supplied computer was integrated with the recognizer, communications equipment, speechware and software. Tests were conducted by ETC. A female voice was used to record words used in feedback phrases.

Tests included voice recognition and feedback. Tests were conducted within a building and from a building across open spaces with distances up to 200 meters. All tests were successful. Figure 2 presents a replica of the "script" used during demonstrations. It was selected to sample many of the capabilities written into the Speechware.

6. Demonstration and training at MIONY:

On July 14th, a demonstration was conducted at MIONY for inspection staff members. Thereafter, 2 inspectors were trained in the use of VABI . Each used the training software tools to generate a voice file unique to each of them. The training sessions took about 20 minutes for each inspector. The training consisted of enrolling each word in the vocabulary, twice, and then using the word (in combination with other words) in a phrase that followed the syntax rules written into the grammar. Both inspectors felt comfortable using the VABI equipment after the 20-minute training session.

Figure 1 Voice Recognition Equipment Overview



* Demonstration only.

Figure 2 Example Script of Voice Activated Barge Inspection

TYPE: 'i'

SAY:

Full Name..... [wait for confirmation]
bulkheads satisfactory
longitudinals unsatisfactory
beams SAT
freeze
decks not_applicable
listen
decks not_applicable
intercostals UNSAT
examined_for_fractures deficient
please_repeat
connections condition okay
review conditions
longitudinals comment
reweld crack as_marked in bay 9 port side
longitudinals comment
renew top 3 ladder_rungs
examined_for_fractures comment
reweld crack weld as_marked in bay 7
examined_for_fractures comment
replace bottom brackets in_way_of forward bulkhead
previous_fracture_repair deficient
previous_fracture_repair comment
reweld third shelf bracket in_way_of aft bulkhead
previous_fracture_repair comment
reweld as_marked peak hatch cover starboard side
previous_fracture_repair comment
remove and make ready for inspection all P_V valves
review previous_fracture_repair comments
review longitudinals comments
quit

7. Field Test aboard a Barge on Staten Island:

The newly trained inspectors then took the VABI demonstration system aboard a barge docked at Caddel's Shipyard on Staten Island, where a field test was conducted. When the communications link between the inspector and the base station was solid, the voice recognition and feedback worked well.

However, communications were inconsistent, breaking up even at short distances and for a variety of base-station antenna placements. Although the day was very hot and the ship was noisy (on-deck air compressors), the spatial consistency of the intermittent operation indicated that the problem was a propagation geometry related problem- the communications was fine at some locations but repeatably broken at other locations.

A debriefing, at MIONY, after the barge test provided inputs for the CONCLUSION section below.

8. Report and Demonstration at CGHQ in Washington DC:

A progress report and demonstration were presented at Coast Guard Headquarters in Washington DC on July 27th. The report included a description of the system, a summary of the tests conducted in New York and the response of the MIONY inspectors and a demonstration. Prior to the demonstration, the system was tested by having the demonstrator walk down the hall while making entries into the VABI. It worked flawlessly! During the demonstration, the identical demonstration procedure resulted in missed recognition at the computer. This was later attributed to the communications base station / computer interface signal level. Voice recognition and feedback were demonstrated on a back-up system.

After the report, a discussion was held on the proper course of further development (see below). Participants included CGHQ personnel, CG R&D Center personnel and the ETC project engineer.

9. Final Letter Report Generation:

A final contractual obligation is the generation of a Letter Report (SOW paragraph 4.2.1) presented herewith.

CONCLUSIONS

The objective of the program was "to integrate computer voice recognition with the MPIU prototype to demonstrate voice recognition to Coast Guard field operational forces conducting inspections aboard vessels" (CG RFQ-006-95 SOW paragraph 2.0). This objective has been met.

Notes on the debriefing after the 14 July demonstrations, training session, and field test was prepared by Bert Macesker of the CG R&D Center and is attached. The conclusions listed below are those that are felt to be most significant.

> The MIONY inspectors said that the voice recognition worked well and was something that they could integrate into their work. The inspectors felt that there would be a definite time savings and increased safety if they could make inspection entries and receive feedback by voice.
>
> Although the demonstration program covered only structural inspection, the inspectors indicated that they would like to use VABI for other barge inspection categories. The inspectors also suggested that it would be valuable to expand communications to include communications between inspectors on the same barge.

The weakness demonstrated during the program was in the communications link between the inspector and the computer based recognizer. Two aspects of the communications system require improvement:

1. The modulation/demodulation system.
2. The packaging of the microphone/earphone/transceiver/battery

Modulation/Demodulation System - The 900 MHz frequency band was selected because of its relatively short wavelength (1/3 meter) which would allow the signal to emerge from hatch openings as small as a 1/2 meter. To verify this choice, a 900 MHz portable telephone was tested aboard a barge at Staten Island. The portable phone used digital modulation and frequency hopping spread spectrum. The tests provided reliable communications from the farthest end of the hold to points on the deck as far as 10 meters from the hatch opening.

For the voice recognition demonstrations, a 900 MHz system from Telenexus Inc. was modified by Telenexus to provide the necessary interfaces. This system used digital modulation but employed direct sequence spectrum spreading. Discussions with the manufacturer and experts in the field have indicated that direct sequence spectrum spreading is susceptible to multipath cancellation. An all-steel barge with many reflecting surfaces provides many opportunities for multipath propagation. Tests of the Telenexus system over paths that entailed little multipath (in the ETC building and through over 200 meters of woodland) showed excellent communication and voice recognition , both before and after the MIONY demonstration. It is concluded that the direct sequence spreading was the cause of the unacceptable communications during the demonstration on the barge.

Frequency hopping is the standard used by most portable communications systems because of its robustness in the face of multipath. A second test was conducted by MIONY personnel to verify the performance of the portable phone. The reports of this test are that it worked well except when the base station was taken inside a house on the

deck. This may have entailed the need for the radio waves to penetrate the house as well as escaping from the hold. It is assumed that if the antenna were placed outside the house, the communications would have been good.

The conclusion is that further experimentation is required. Topics that require investigation include:

1. Frequency (both 900 MHz and the new 2.5 GHz band)
2. Spread spectrum method
3. Placement of the base station antenna

It was suggested, at the Coast Guard Headquarters demonstration, that it would be desirable to have the base station mounted inside the inspector's vehicle. This would eliminate the need for a power source aboard the barge and would eliminate a hardware security problem. This suggestion is definitely worthy of further investigation. A related experiment would entail the use of a long cable between the vehicle and a deck mounted base station antenna. In this case, all of the equipment, other than that worn by the inspector, would remain in the inspector's vehicle- except a small antenna, magnetically fastened to the deck. The antenna would receive the radio transmission from the inspector's portable unit and would pass it to the vehicle mounted base station via a coaxial cable. The cable would be thrown from the barge to the dockside, prior to the start of the inspection. In this manner, the radio transmission would be required only to communicate successfully onto the deck, and would not also be required to be reflected down to the vehicle.

The program has conclusively proved that when the communications path is solid, the recognition and feedback work well.

Packaging - The system that was used for the demonstrations employed a directional microphone attached to "ear-muff" earphones. A wire went to the transceiver that included the antenna and battery and fit easily into the vest pocket. The MIONY inspectors were happy with this packaging. Others have suggested that other forms of microphone (bone-conduction, throat) and earphones (hearing aid style) be investigated to combat ambient noise and to reduce size and weight. Consideration should be given to mounting the antenna, microphone and earphones on the hard hat with a line to the pocket or belt mounted transceiver/battery.

RECOMMENDATIONS

Although there are several steps that need to be taken before an operational device is ready for routine use in barge inspections, most of these are straight-forward. They include:

1. Expanding to other inspection categories.
2. Expanding the comments vocabulary.
3. Making the training software more user-friendly.
4. Providing inter-inspector communications.
5. Expanding the nature and scope of feedback to include prompts.

The immediate engineering hurdle that needs to be surmounted is the optimization of the communications modulation/demodulation, the optimum placement of the base station antenna and the packaging of the inspector's communications terminal.

It is therefore recommended that the Coast Guard publish a "Sources Sought" request in the Commerce Business Daily. A suggested specification for the "Sources Sought" is attached. When the responses are received, it is recommended that ETC be employed to evaluate responses, conduct in-depth investigations of promising responses and design field tests that could be used to evaluate performance prior to a full-scale demonstration on a barge. This would permit a phased development approach.

It was suggested, at both the MIONY and CGHQ demonstrations, that it would be valuable to have a "voice-mail" add-on capability at the base station. With such a capability, the inspector could annotate his inputs with comments that are not included in the vocabulary recognized by the recognizer. Voice control would be used to initiate and terminate this mode. The inspector would need to make the permanent entry at a later time. It is recommended that both the hardware and software/speechware aspects of this capability be investigated and bread-boarded.

COMMERCE BUSINESS DAILY- SOURCES SOUGHT ANNOUNCEMENT

The Coast Guard R&D Center is seeking information on communications products with the following characteristics:

1. Full duplex voice communications in the 900 MHz or 2.5 GHz band, between a base station and 2 or more portable units.

2. Frequency hopping spread spectrum.

3. Battery operation of the portable units with a minimum of 3 hours battery life. The batteries must be easily and rapidly re-chargeable.

4. The portable unit packaging should be compatible with a hard hat and leave the user full freedom of his or her eyes and hands .

5. Packaging of the base station in a computer docking station.

6. Ranges up to a 1000 feet in a ship environment.

7. Rugged construction.

8. Controls limited to ON, OFF, VOLUME, CHANNEL SELECT.

9. Inexpensive.

10. Safe in explosive atmospheres.

Notes on MPIU Voice Recognition Technology Demonstration at MIONY prepared by Bert Macesker of the CG R&D Center

A one-day demo was held at MIONY to evaluate the feasibility of using voice recognition technology to capture marine inspection data in the field. The demonstration was held at MIONY and Caddel Shipyard on 14 July 1995. In attendance were:

Mr. P. Sielman (Engineering Technology Center)
Mr. R. Desruisseau (CG R&D Center)
Mr. B. Macesker (CG R&D Center)
LT E. Bernholz (CG MIONY)
CWO D. Lajavic (CG MIONY)
ENS D. Miller (CG MIONY)

The objective of the technology demonstration was to integrate a simple voice recognition capability with the MPIU software to assess its feasibility, i.e., can voice recognition provide inspection inputs and feedback while keeping the inspectors hands and eyes free.

The communications in the tank between the base computer and remote transceiver on 14 July were inadequate. Previously a test was conducted on 10 May 1995 to assess communications specifically. In the previous test a 900 MHz cellular phone was used which employed digital modulation and frequency hopping spread spectrum. The results were better than expected. Communications with the inspector walking around in the tank and a person at various locations on the deck was very good. The test on 14 July was conducted on a tank barge of similar size and arrangement with a 900 MHz system using direct sequence spectrum spreading. Communications broke up as soon as the inspector entered the tank a depth of 20 ft or more.

LT Bernholz said that they would re-create the same test using the cellular phone that Mr. Sielman left behind. The premise was that if the communications were successful with the phone then it could be assumed that the communications problem on 14 July lie with the antenna system.

Training

The inspectors felt that training on the voice system went well.

Computer Voice Recognition

o The inspectors agreed that the voice recognition worked well and was something that they could integrate into their work.

o The inspectors suggested that an additional feature that would attach a free-form narrative to a inspection category or item would be a benefit. For example, an inspector might encounter a problem that needs a unique description different from standard responses programmed into a voice vocabulary. The marine inspector would say, "Freeze, enable diary!" After the narrative was complete the inspector would say "Disable diary, listen!" to get back to the inspection program. A flag for each voice diary annotation

would need to be incorporated into the MPIU record that would associate those specific diary references to specific inspection categories.

o A concern expressed by one inspector was that more focus be placed on the administrative time in front of MSIS instead of field data capture. He felt that too much emphasis is being placed on studying the electronic data capture in the field. It was explained that this projects focus is on proving that the front end of the computer based system, i.e., MPIU works and that its success would mean that a complete inspection file would be created in the field thereby eliminating existing administrative time in front of MSIS.

o It was asked if the SPINDRIFT reference library could be accessed with a voice capability. The consensus was that inspectors would look up references back in the temporary office with the laptop or pen computer. There are text-to-speech synthesis capabilities available. However, it was decided it would be difficult to assess their utility without testing.

o It was suggested that additional feedback would be needed in addition to "Review Conditions" to indicate to the inspector if he missed the inspection of any items, e.g. "Double-check" for that specific vessel. This would be something an inspector might do before he leaves a tank space. Mr. Sielman explained that this would be easy to do and represented a simply software modification.

o Some ideas were tossed around with regards to the optimal configuration of the voice hardware on the inspector. The consensus was that having the antenna on the hard-hat and remote transceiver in the coveralls pocket was best. Putting them all in the hard-hat would make the hard-hat too heavy. Adding a lanyard to the remote transceiver to tie it off for added security would be beneficial.

o One inspector suggested the idea for multiple inspectors on a vessel being able to talk to one another using the voice capability. He felt a need to know what was going on between different inspectors. For example, coordination might be required on a tank vessel examination between a machinery and hull inspector working on the same inspection schedule. Multiple inspectors could talk to the computer at the same time but each inspector would need his own voice card in the computer.

Time Savings

o The inspectors felt that there would be a definite time savings using a voice recognition capability with an effective user interface. It would need to have a large enough vocabulary. It was expressed that sometimes when an inspector is forced to write things down in tight, uncomfortable, and maybe sweltering spaces they end up with not being able to discern their own writing. Voice recognition would eliminate this problem.

Distraction Using Voice Recognition

A question posed was "Assuming you were thoroughly trained with a voice capability - would you consider its use a distraction while conducting the inspection?" This was a concern expressed in previous field demonstrations with the use of a pen tablet inside a tank space. The fear was that the computer would detract too much visual attention from the actual inspection process thereby increasing the opportunity to miss a problem or not being as safety conscious.

The inspectors felt that it would not be distracting at all. It would be better since, ideally with the voice system, you would not even have to use a pen and notebook anymore.

Other Applicable Inspections

It was felt that this could be used on any type of vessel. If it got to be easy to use they would envision an expansion of its use from structural to lifesaving category inspections as well as others. It was asked if they could switch from one category to the next using voice recognition. Mr. Sielman answered yes and that this was a straight forward software issue. For example, specific default words could be used to switch back and forth between categories.

Location for Voice Receiver/Laptop

It was asked "What is the optimum location for the voice receiver/laptop?" Concern was expressed that it would need to be placed someplace safe both from the elements and from accidentally bumping into by the shipyard workers. Safe places include the Captain's cabin or near known shipyard workers on the deck. Should consider a bolt-down-lock-down mechanism so that the voice receiver/laptop could not be moved.

Background Noise

It was asked "What kinds of background noises would a computer voice capability have to contend with?" The inspectors considered the barge the test was conducted on to be relatively quiet. The only noise on 14 July was an air compressor. There weren't any 'knuckle busters' on deck, i.e., workers using air hammers. The CG inspectors also make noise with chipping hammers, etc. One inspector suggested a re-calibration scheme for background noise. Mr. Sielman explained that capability already exists. For example, a function exists where you could say "calibrate" at which point the recognizer would listen to the background noise and adjust the internal signal to noise of the system.

It was suggested that a throat or bone microphone would cut down on background noise interference.

Location of Remote Transceiver

The inspectors suggested using an antenna integrated with the hard-hat with a wire

running down to pocket remote transceiver. One inspector suggested moving away from a voice microphone. His concern was that inspectors might be worried that the recognizer was recording everything said, i.e., would he have to watch his language and would it intimidate interactions with the ships crew in soliciting inspection information.

Inspection Quality Using Voice Recognition

It was asked "Would voice recognition technology improve the quality of the inspection data gathered in terms of having a structured voice inspection procedure?" The consensus was that anything that would make the job easier such as a voice capability would facilitate the job and improve the accuracy of the inspection data gathered.

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APPENDIX B

Marine Portable Inspection Unit (MPIU) Functional Description

Marine Portable Inspection Unit (MPIU) Functional Description

The MPIU Functional Description (FD) provides a description of the hardware and software needed to implement a portable marine inspection capability for Coast Guard Marine Inspectors. The basis for the preceding system description is derived from the following studies.

- o "Assessment of the Coast Guard Marine Safety, Security, and Environmental Protection (M) Program," Coast Guard Report No. CG-D-11-89
- o Field survey results documented in Coast Guard Report No. CG-D-05-93 "On-Site Marine Inspection Data Capture"
- o Evaluation of a technical demonstration of prototype MPIU systems at the Marine Safety Office in New Orleans (MSONOLA)documented in Coast Guard Report No. CG-D-28-94 "Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU)"
- o Evaluation of a technical demonstration of enhanced prototype MPIU systems at the Marine Inspection Office in New York (MIONY) documented in Coast Guard Final Report "Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU) - Phase 3" (This FD is an Appendix to this report)

DOD-STD-7935A was used as a guide for the functional description that follows.

1 GENERAL

1.1 Purpose of the Functional Description

This functional description for an on-board and on-site Marine Portable Inspection Unit (MPIU) capability is written to provide:

a. The system requirements to be satisfied which will serve as a basis for mutual understanding between the user and the developer.

b. Information on conceptual performance requirements, preliminary design considerations, and user impacts.

c. A basis for development of a program for implementation of computerized inspection data management for field use by Coast Guard Marine Inspectors.

1.2 Project References

These studies have been conducted by the U.S. Coast Guard's Research and Development Center in Groton, CT for the Merchant Vessel Compliance Division (G-MCO-2) at Coast Guard Headquarters in Washington, D.C. The roles of contractors tasked in support of this project are:

- o MAR, Incorporated was tasked with performing a Marine Inspector field survey and initial function description under Contract DTCG39-91-D-E33A21, Delivery Order DTCG39-92-F-E00184 documented in Coast Guard Report No. CG-D-05-93, "On-Site Marine Inspection Data Capture"
- o MAR, Incorporated was tasked with developing a working prototype of an MPIU system and a technology demonstration of the system at MSONOLA under Contract DTCG39-91-D-E33A21, Delivery Order DTCG39-93-F-E00465 documented in Coast Guard Report No. CG-D-28-94, "Evaluation of a Coast Guard Marine Portable Inspection Unit (MPIU)"
- o Patriot Systems was tasked with customizing an electronic reference library for Marine Inspectors under a Small Purchase Order No. DTCG32-95-P-E00059
- o Patriot Systems was tasked with providing MPIU software enhancements under Small Purchase Order No. DTCG32-95-P-E00270
- o Engineering Technology Center was tasked with performing a voice recognition technology demonstration using the MPIU software under a Small Purchase Order No. DTCG32-95-P-E00312
- o PSI, International was tasked to perform a Cost/Benefit Analysis under a Small Purchase Order No. DTCG32-95-P-E00313

1.3 Terms and Abbreviations

On-site computer - refers to the computer used by the inspector while making inspection rounds on the ship.

On-board computer - refers to the computer used on board ship in a stateroom or other climate controlled space. The on-board computer is usually used on a desk or table with the inspector seated.

Marine Safety Information System (MSIS) - refers to the present Coast Guard's integrated system for providing information to support the operation, management, and decision-making functions of Marine Safety activities. MSIS merges information from field activities into a common information base which can be shared by all users, and which builds performance histories. MSIS is accessed from the Coast Guard's present standard workstation (CGSWSII).

Marine Safety Network (MSN) - refers to the Coast Guard's marine safety database and computer network linking marine safety offices which will replace the existing MSIS system in several years.

Marine Portable Inspection Unit (MPIU) - refers to the computer inspection system and its peripherals used in the field, on-site at a vessel or at one of the MSO/MIO satellite offices

CG*SWIII* - refers to the new Coast Guard standard workstation which represents the Coast Guard's microcomputer architecture through the year 2000; both workstations and portables are a PC architecture 486 and/or Pentium based with Microsoft Windows NT; Word and Excel represent the word processing and spreadsheet tools

Marine Inspection Pre-Inspection Package (MIPIP) - refers to the inspection information that is normally retrieved from MSIS in order to initiate an inspection; it is assumed that there will be a similar file available on the new MSN that facilitates the initiation of the inspection process

2 SYSTEM SUMMARY

2.1 Background

The purpose of the MPIU system is to streamline the management of collected inspection data and background reference information used by Coast Guard Marine Inspectors during vessel inspections.

The Coast Guard is required by Title 46 , U.S. Code to periodically inspect certain vessels registered in the United States or operating in U.S. waters to verify seaworthiness, structural integrity, and passenger and crew safety. Inspections also verify conformance with the pollution laws of Title 33, USC. Virtually all cargo carrying and passenger vessels which use U.S. ports are subject to Coast Guard inspection. A large number of previously uninspected U.S. registered commercial fishing vessels have recently become subject to inspection under the Commercial Fishing Industry Vessel Safety Act of 1988 and the regulations resulting from that legislation.

The Coast Guard maintains a corps of several hundred professional inspectors to carry out its inspection responsibilities. Most inspectors are uniformed Coast Guard officers, warrant officers, or senior petty officers, and there are few civilians who have inspection duties. Most of these inspectors are based at regional Coast Guard Marine Inspection Offices (MIOs) or at the inspection departments of regional Coast Guard Marine Safety Offices (MSOs) under the direction of the local Officers in Charge of Marine Inspection (OCMIs) and the Chiefs of Inspection Departments (CIDs).

The data flow to be managed by the MPIU system will begin and end at the MSN. However, the MSN will be required to electronically feed the MPIU system with background vessel inspection histories, update reference libraries, and receive a completed vessel inspection from the MPIU system. No additional interaction between MPIU and MSN will be required.

2.2 Objectives

The objectives of the MPIU system are to increase the efficiency and effectiveness of Coast Guard vessel inspectors and to reduce the time between inspections and information availability on the MSN. The MPIU system will eliminate needless steps of transcription, copying, and re-typing of inspection information between the inspection site and office. The current, hand-written inspection CG 840 series books will be replaced by electronic equivalents in most cases. The system will provide better management of the large amount of reference information needed by inspectors. The system will utilize nondevelopmental hardware and software to the greatest extent possible.

2.3 Existing Methods and Procedures

The inspection process begins when an inspector obtains a printout of the Marine Inspection Pre-Inspection Package (MIPIP) from the existing Marine Safety Information System (MSIS). The inspector assembles a package of reference material applicable to the inspection before leaving the home office. Although, marine inspectors are trained to have a working knowledge of U.S. and international laws and regulations so that he or she can recognize a deficiency quickly, they must often prepare an extensive package of reference materials to bring with them to the vessel.

The primary data collection device presently used by inspectors is paper and pencil. Paper inspection booklets (CG-840 series) are filled out during and after the inspection, and the inspector prepares a diary of the inspection. If deficiencies are found, form CG-835 is issued. These documents (inspection booklets) are the official permanent record of the inspection, and are retained in the inspection office at the vessel's port of registry. The first draft of the diary, prepared on-board the inspected vessel or soon after the inspection, is usually handwritten, with the permanent smooth copy produced at the office using a word-processor. A brief summary of important inspection data based upon the information in the inspection booklets, the diary, and the CG-835 form is entered into the MSIS database after encoding.

Many inspection offices employ a full-time data entry staff. For example, an administrative staff of three are presently assigned to MIO New York. Although many marine inspectors are now entering their own inspection data to help speed up the process, they often print out copies of MSIS product sets and write in what they want changed. The administrative staff take these hand-written notes and enter the changes manually.

Delays are inherent in the present system from the time an inspection is initiated which includes the time it takes to obtain the MIPIP from MSIS until the information becomes available on MSIS. These delays arise from several causes. Inspectors' workloads and the need to coordinate inspectors' schedules with vessel in-port availability often prevent inspectors from making MSIS entries immediately after an inspection is completed. In many of the offices the number of Coast Guard standard terminals available to inspectors is limited. Detachments from the main office located in or around shipyards usually do not

have CGSWSII terminals; therefore, inspectors are tied to inefficient travel to and from the main office each day to exchange inspection information. Many MSIS data entries are multi-character alphanumeric codes; any codes slightly out of the ordinary must be looked up by inspectors in a reference book as they enter their inspection data.

Following administrative validation, the information in the MSIS becomes available to all MSIS users. Figure 1 and 2 illustrates the simple data flow.

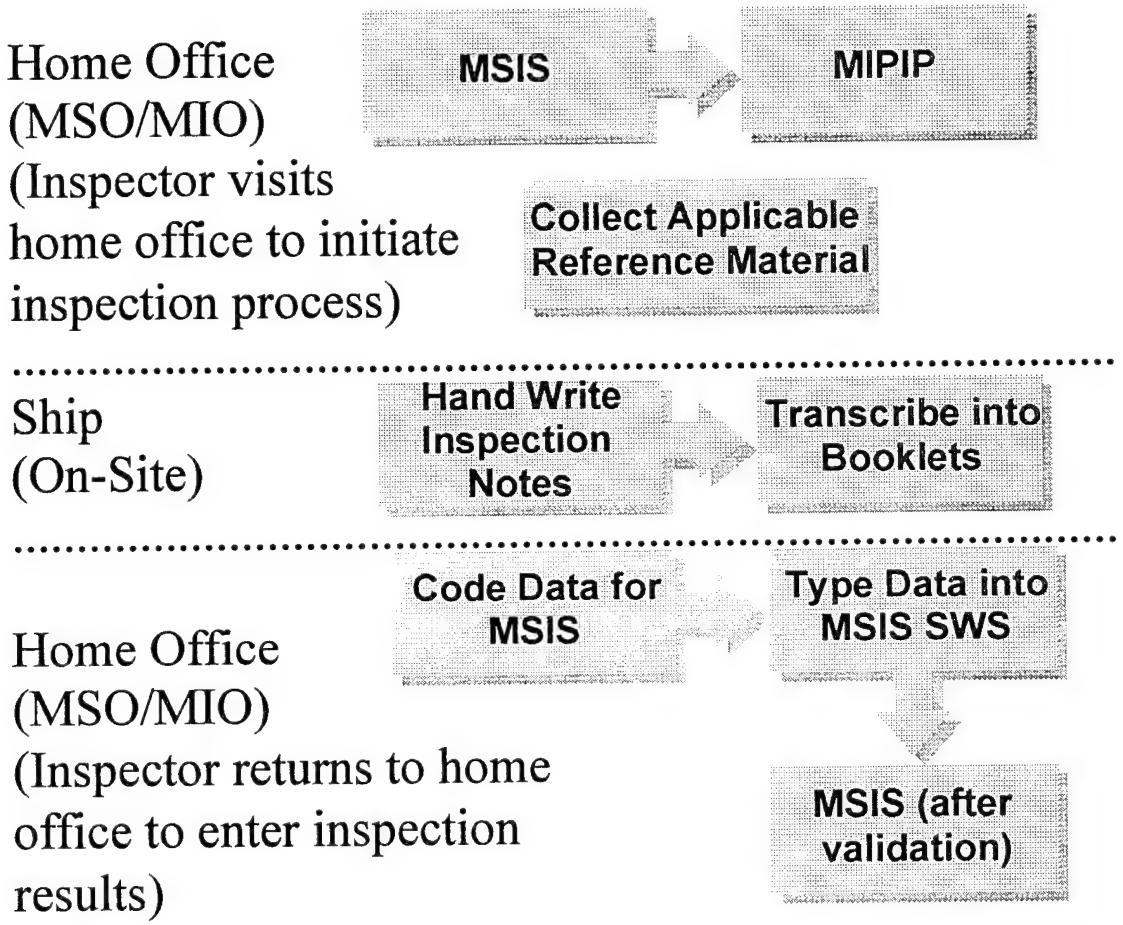


Figure 1. Diagram of Existing Inspection Data Management

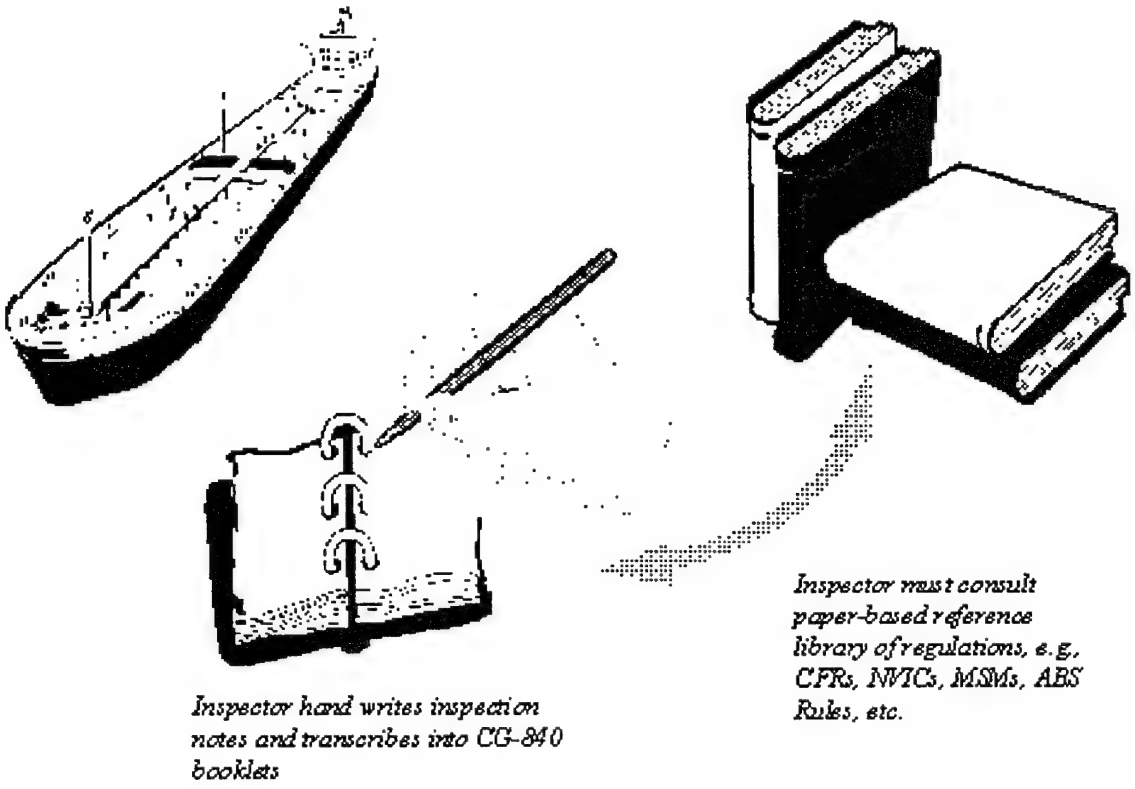


Figure 2. Existing Manual Inspection Data Capture On-Site at Vessel

2.4 Proposed Methods and Procedures

The proposed MPIU system is a computer-based system utilizing a hand-held, pen-based computer for on-site or mobile data collection and an on-board keyboard-based desktop notebook computer. The MPIU can be a hybrid pen-based and notebook computer. The pen-tablet can be detachable from the keyboard/notebook for performing inspections of items on the vessel.

The on-board configuration remains in the vessel's stateroom, bridge, or temporary office in the shipyard. A menu-driven, vessel specific computer program running on the MPIU will replace the use of inspection booklets. The MPIU computer, in either notebook or pen-tablet form, will offer inspector's electronic on-line access to reference materials that they require. The MPIU will allow the inspector to record textural comments, sketches of structural details or inspection items, transfer inspection files from one MPIU to another via a modem or direct computer connection, upload and download MSN inspection data, automatically retain and track deficiencies at a local level, print worklist items where worklist items can be automatically converted to CG835s if unresolved, print certificates in the field, and digital photographs for incorporation into a comprehensive inspection file. Figure 3 and 4 illustrates the data flow for the proposed MPIU system.

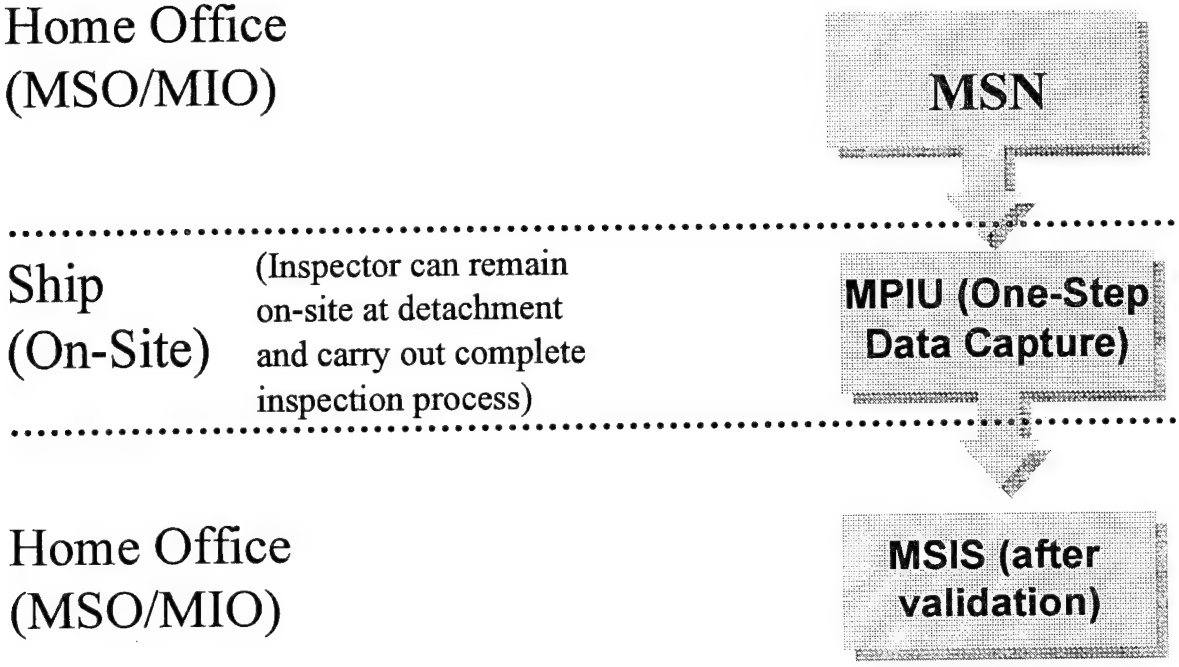


Figure 3. Proposed MPIU System

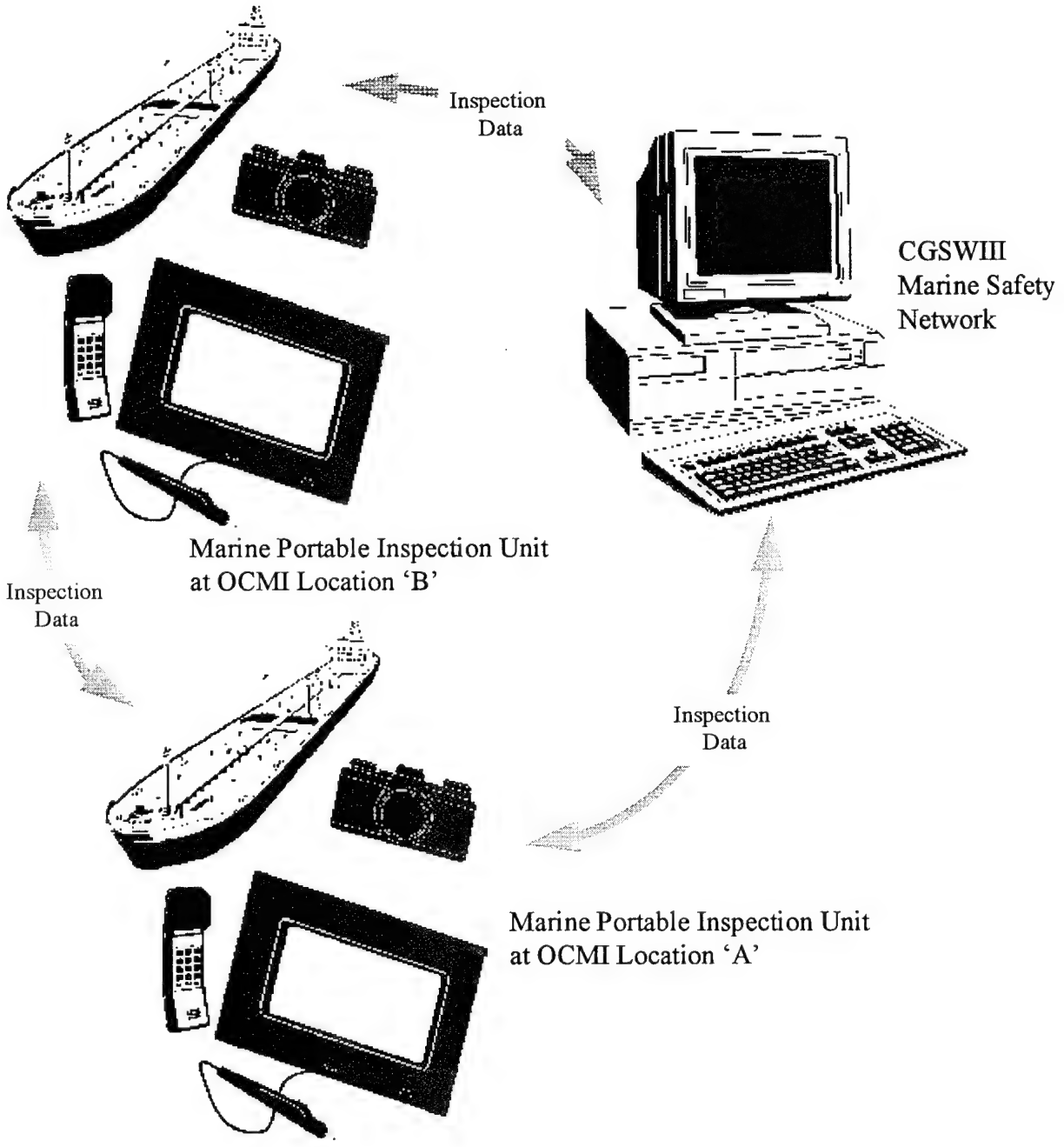
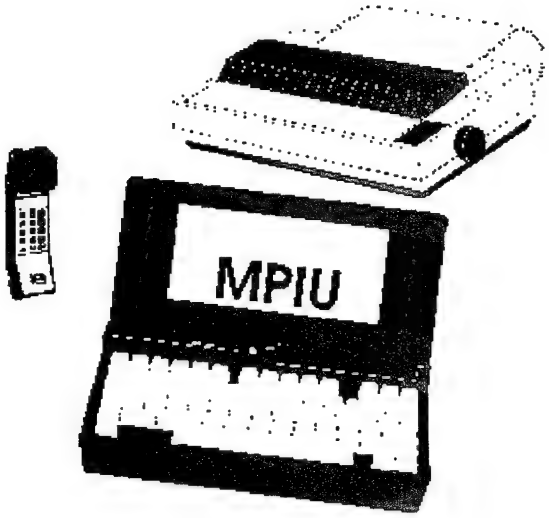


Figure 4. Information Exchange in Proposed MPIU System

The MPIU (used in its notebook role) will be carried on-board the vessel being inspected, but may not be hand-carried to the actual inspection site in all situations. It will provide text processing for diary preparation and for filling out and printing necessary inspection forms and for communicating with other MPIU systems. The MPIU reference library will be the same whether used in the on-board or on-site configuration. Figure 5 illustrates the on-board and on-site MPIU configuration.



On-Board MPIU
System Configuration

On-Site MPIU
System Configuration

Figure 5. On-Board and On-Site MPIU Configuration

When an inspector returns from the on-site inspection to the on-board location he or she will complete the inspection file for transmittal to MSN. A phone-line modem will be used in two-way communications between the main inspection office, e.g., MSO or MIO, for transferring the completed inspection file or down-loading MIPIPs to initiate a new inspection.

The MPIU system will have the following special features.

template drawings General template bitmap images of structural details, machinery, pumps, etc. will be available to attach to specific inspection items; standard CAD drawing images will be available.

digital photographs A pocket-size, i.e., must fit in marine inspector's coveralls, portable digital color camera with non-volatile memory; 32 frame capability; automatic flash, close-up, and on-demand image/picture viewing capabilities.

linked reference library	A comprehensive electronic reference library comprised of Category 1 and 2 reference materials; with options to carry Category 3 reference materials in the on-board MPIU configuration.
reference search capability	The MPIU can launch directly into the reference library to conduct keyword and key phrase searches from any level in the program; the inspector will have the ability to customize hypertext links of memory jogger items to specific regulations.
MIPIP to MPIU interface	A conversion routine will reside on the MPIU that will transfer the entire MIPIP to appropriate MPIU fields via a modem or direct CGSWSIII to MPIU communication.
MPIU to MSN interface	No detail requirements have been developed for this; at a minimum MPIU software must automatically code and export all of the inspection data captured with the electronic version of the 840 book into a file of required MSN data; it is desirable to have digital MPIU captured images stored in MSN directly or in a separate file with some indicator that inspection images are available for that particular case.
electronic inspection forms	All of the CG-840 series paper-based inspection forms will be in electronic computer graphical user interface (GUI) format either in a functional or compartmental configuration.
deficiency database	A field use database will reside on the MPIU for tracking local deficiencies encountered; the database has the general capability of viewing, printing reports, or sorting inspection data to review all deficiencies for a specific vessel or class of vessel, and generate a certificate history file, deficiency history reports and case reports; sorting and report printing can be further limited based on location, type, cause , sub-system, and inspection item specifics; note that this does not take the place of the global tracking of performance histories maintained by MSN but provides a local and on-site level of performance tracking of a vessel.
worklist generator	The MPIU program will have the feature of generating worklist items from MPIU inspection items that will be field printable on-demand; if worklist items are not resolved the inspector can have the MPIU convert to an 835 deficiency.
merge feature	Two or more independent inspection files of the same inspection can be electronically merged into one coherent file.

MPIU-to-MPIU modem interface The transfer of MPIU inspection files will be facilitated by compression and decompression routines built into the communications program which will be transparent to the user.

diary A rough diary will reside in the MPIU computer which will permit text entry by electronic pen or through an attached keyboard [a Coast Guard standard word processing package will be used for the final smooth diary and narrative].

field printable inspection certificates Most commonly used inspection certificates, e.g., CG-854, CG-840s-1(-2), and CG-5352 for tankships and barges, will reside in the MPIU in electronic form and will be automatically updated with available information collected as part of the inspection file; the certificates are printable on-site with a portable printer [a history file will track each issued certificate].

report printing Report printing options will include case reports, certificate history file reports, deficiency history reports and worklists with options of printing attached electronic inks, templates, and digital photographs (in black and white) printable on-demand.

A couple of special feature options will remain under consideration during system development and include:

compartmental architecture A feature that requires additional study and involves using a compartmental based organization to the computer inspection program which would configure the program to keep all of the entries for a given shipboard space together; in a compartmental strategy it would need to be determined which systems are likely to occur in which compartments and would also require the development of generic lists of compartments for different classes of vessels; although, a compartmental system represents more programming effort than a system based approach employed in this FD it should remain a future consideration.

voice recognition overlay Voice recognition user interface requirements are beyond the scope of this FD; however, the architecture of the MPIU program must be demonstrated to be capable of supporting a future introduction of voice control for inspections that can't support the presence of an on-site MPIU unit, i.e., aspects of inspections that require extreme mobility where safety is a key issue.

2.4.1 Summary of Improvements

The specific cost/benefits associated with a MPIU system will be addressed in a separate published report. In general, for each vessel inspection, the inspector can choose to devote more time to the physical part of the inspection or alternatively save vessel down-time imposed on the shipowner by performing more efficient inspections.

The MPIU system will give inspectors access to more information about past inspections regardless of the location of the inspectors. Access to textural, graphical, and pictorial reference material will be greatly improved, not only in terms of the amount of material directly accessible on-site and on-board, but also in terms of the speed of access and the accuracy of the searching process. The comprehensiveness of a search for the reference, regulatory, and policy guidance reference materials applicable to a given situation will no longer be dependent upon the accuracy of the individual inspector's memory.

Multiple steps of transcription, copying, and re-typing of inspection data will be eliminated between the actual collection of the data on-site and the final permanent records of the inspection including coding the information for MSIS. Once the on-site data is entered on-site, all data manipulation other than editing will be eliminated.

Functional improvements will include the availability of reference materials to the inspector on-site and the availability of graphical data such as on-site free-hand sketches, sketches or structural detail templates, and digitally stored photographs.

2.4.2 Summary of Impacts

Impacts will include initial training of users and maintenance personnel, the establishment of maintenance procedures and responsibilities in inspection offices, and ongoing training for new users. A continuing program to provide comprehensive and up-to-date reference material will be required. It will include Coast Guard Headquarters being responsible for the electronic dissemination of material such as CFRs, MSMs, and Headquarters initiated NVICs and Policies and the marine inspection units who will have to include local policy information.

2.4.2.1 User Organizational Impacts

a. Training of Users

Inspectors will have to be trained in the use of the new system. This training is expected to take from two days to one week per person. If the MPIU data capture is made to be functionally familiar to existing paper-based practices the training is expected to be successful in this time frame. Training that inspectors receive on the new CGSWSIII will provide a solid background for developing expertise with the MPIU operating system. The training of the initial users will need to be done either at a central location or by a traveling

training unit. All training, at least initial training, should be performed by the same instructors to assure consistency in usage throughout the field.

MPIU units should be made available to inspectors who attend inspector workshops and specialized training at facilities like Yorktown. Although, the hardware and core software are to be the property of the inspection office, the customized and/or personalized software should be retained by the inspector throughout his or her field level marine inspection career. This software represents the individualized hypertext links to references, the template sketches of various inspection items, or digital pictures which make the inspector more efficient and effective in the field. Throughout the marine inspector's field career he or she will obtain training material in electronic format that can be integrated into the inspector's assigned MPIU unit and personalized software.

It is anticipated that new users will function at less than full efficiency during their first few weeks using the new system.

b. Maintenance and Training of Maintenance Personnel

The MPIU system will replace many aspects of the existing manual system. Therefore, maintenance of portable computer hardware and software will be a new function or added responsibility to the inspection office system manager.

At least one person in each office, i.e., MIO, MSO, or large inspection detachment, will have to be given responsibility for physical maintenance of the hardware, replacement of defective units, acquisition of new and replacement equipment, and property control. Additional responsibilities will include system software installation, maintenance, and upgrading of such items as structural detail templates, new policy letters, or maritime regulation changes. In a busy office (15 or more inspectors) these responsibilities would be expected to translate into a quarter man-year and could be assigned as permanent collateral duty. In very busy offices, the proposed system will require that one person be occupied half-time in computer system support. MPIU hardware will be off-the-shelf and therefore no specialized electronic skills (ET rates) are required.

Maintenance of the reference database to keep it current is a new task imposed by the adoptions on the MPIU concept. Updates will be received through either MSN or attached files to electronic mail on the CGSWIII but will require the system manager to confirm updates on MPIU units so that inspectors can have field access to the most recent changes to any rules and regulations.

A designated and secure space is needed in the main office where inspectors can check out fully charged gear, such as digital cameras, printers, computers, etc. The MPIU equipment locker requires a rack of plug-in outlets for recharging of MPIU gear.

c. Inspection Preparation/Completion Procedures

2.4.2.2 User Operational Impacts

The MPIU system will fundamentally change the way inspectors perform their duties, but will not alter the Coast Guard business of marine inspection services to the public in general. Most of the information which inspectors need will be available through the system, and virtually all of the inspection data they generate will be entered into and processed by the MPIU system.

a. Quantity of Background Information Available

The MPIU system will make the reference, regulatory, and policy guidance materials which inspectors use available to them on-site. Inspectors are currently able to carry a few of the most frequently referenced documents with them in hard-copy form. The MPIU system will provide enhanced access to these materials by linking them to appropriate sections of the electronic inspection booklets, and providing key-word and hypertext searching capabilities.

Additional vessel information will be available on a field level on-site. More detailed records, including electronic worklists of previous inspections will be available on the MPIU system. This provides advantageous insight into specific vessels or class of vessels routinely inspected. This information will allow inspectors to budget their inspection time more effectively, concentrating on areas in which deficiencies are more likely to occur based on past inspection experience.

b. Quantity of Inspection Data Handled

The MPIU system will allow a much larger amount of inspection data to be handled efficiently than the present system allows. In addition to the data capture of the electronic inspection books, the inspector will record sketches and digital photographs for direct incorporation into the official inspection record. Digital storage of expanded inspection documentation will provide inspectors with quick and efficient access to the larger amount of information about past inspections which inspectors have indicated strongly as something they desire.

2.4.2.3 User Development Impacts

A pilot study with a fully functional MPIU capability in one selected inspection office is recommended before full-scale implementation takes place. A pilot study goes beyond the technology demonstrations that have already been performed and requires a complete two-way prototype interface with MSIS to completely evaluate the office-wide impact of transitioning over to an MPIU system. This pilot study would provide data to evaluate both the functionality of the software and the nature of user developmental impacts.

2.5 Assumptions and Constraints

A new Marine Safety Network (MSN) has been under development for several years and will replace the existing MSIS. While the functional description assumes that all desired data storage will be incorporated, this may not be the case once the MSN database is finalized. Thus some information from MSN may not be available for the MPIU system.

3 DETAILED CHARACTERISTICS

3.1 Specific Performance Requirements

a. Office Terminal to MSN

The CGSWSIII office terminal will provide a link between MSN and the MPIU systems. The MPIU units will have the optional ability of uploading and downloading files the same as office terminals. The development of interface requirements for MSN was not part of this study but in order for the MPIU capability to be integrated with MSN, MSN must perform a few basic functions. The CGSWSIII must retrieve vessel specific inspection files, past inspection data, an equivalent to the MIPIP, waiver information, and ship inspection status from MSN. The MPIU will import then convert the MSN MIPIP data into MPIU fields in preparation for an inspection. The MSN will require a conversion routine to sort the completed and validated MPIU inspection file into the appropriate MSN product locations.

b. MPIU On-Board Computer Configuration

A notebook or hybrid pen-computer will be used as a base station for inspections at a temporary office in the shipyard or on-board the ship on the bridge, stateroom, or other convenient location. The on-board computer may consist of the new CGSWSIII notebook available on the Coast Guard contract. This computer will have the following performance features:

- All of the special features described in Section 2.4.
- A high level word processing program must be included to allow the inspector to prepare the final smooth inspection diary or Marine Inspection Narrative Supplement (MINS). It is anticipated that this will be the same word processing package standard on the CGSWSIII.
- A complete reference database of Category 1 and 2 references described in Section 3.4. The database will be supplemented with Category 3 reference material on a case by case basis.
- Applications to download and upload data between the on-board, on-site, and office terminal are required. These programs must have the ability to merge data from multiple on-site computers into a common inspection file.
- A printer driver for the on-board computer is required.

- o An interface application program for uploading, downloading, editing, and printing color digital photographs is required.

c. MPIU On-Site Computer Configuration

One or more on-site pen-based computers will be used by inspectors as they make their inspection rounds. An on-site computer may be needed for each inspector in the inspection party but only one on-board computer is required per any one vessel inspection. The on-board computer will be used to merge the data captured by multiple inspectors and their computers into one file. The on-site computer must have all of the special features described in Section 2.4.

3.1.1 Accuracy and Validity

The applications to be employed are mostly database management complemented by word processing types of applications. The MPIU system must accurately retain and transfer inspections data but a high level of math processing is not required. The introduction of CAD capabilities will require some math processing. However, it is anticipated that any graphics generated on high level systems such as AutoCad will be cross imported as specific picture files.

3.1.2 Timing

Response time is an important issue with regards to the MPIU application. The applications developed must respond without significant perceptible delay. Future modifications to the software to upgrade the MPIU software by adding more graphics must be monitored and may require the developer to exercise efficient procedures to handle GUI screens and data.

Down loading and uploading of inspection data between the MPIU and MSN will usually be performed remotely using a telephone modem. Compression routines and high-speed modem rates will be employed to minimize transmission delays.

3.1.3 Capacity Limits

a. MPIU On-Board Computer Configuration

All storage will be on the internal hard drive. The MPIU will have both Microsoft Word (approximately 25 MB storage space required) and Microsoft Excel (approximately 22 MB of storage space required) but an estimate for the word processing/spreadsheet CGSWSIII software will be estimated with the storage required for Microsoft Office for Windows NT (approximately 90 MB storage space required). Conservative estimates are made on working MPIU inspection files and miscellaneous software. The storage capacity limits for the MPIU on-board configuration are:

- Storage for Category 1 reference materials - 8 MB
- Storage for Category 2 reference materials - 80 MB
- Storage for some of Category 3 reference materials - 60 MB
- MPIU electronic inspection book programs - 10 MB
- Working MPIU inspection files with attached digital pictures - 40 MB
- CGSWSIII word processing package - 90 MB
- Misc. Camera Software, email, communications, etc. - 5 MB

Approximate Total 300 MB

The on-board configuration located at a remote site from the main office will require added peripheral storage for on-going inspections and temporary local storage of completed inspections. This requires the use of back-up drives with limitless storage potential such as a zip drive which can be driven off the on-board computer's parallel port. The backup drive would store inspection data with digital images to 100 MB disks similar in size to standard 3 1/2" floppies.

b. MPIU On-Site Computer Configuration

All storage will be on the internal hard drive. The storage capacity limits for the MPIU on-site configuration are:

- Storage for Category 1 reference materials - 8 MB
- Storage for Category 2 reference materials - 80 MB
- Working MPIU inspection files with digital pictures - 10 MB
- CGSWSIII word processing package - 90 MB
- Misc. Camera Software, email, communications, etc.- 5 MB
- MPIU electronic inspection books - 10 MB

Approximate Total 200 MB

3.2 Functional Area System Functions

The MPIU functions have been subdivided into four general steps discussed below.

a. Coast Guard Standard Workstation- Output

An inspector will retrieve information from the MSN which includes database information, text, drawings, and photo files by the most convenient method. The inspector who begins an inspection from the office will either copy a MIPIP file from CGSWSIII to disk for uploading into his or her MPIU in the field, use a direct cable computer link between the MPIU and CGSWSIII, or download MSN data over a modem to a remote MPIU unit. Any locally stored inspection information, past inspections of the same vessel, or similar vessels, is also retrieved that may be waiting for validation for inclusion in MSN.

b. MPIU On-Board Computer Configuration

The inspectors take the MPIU on-board configuration and its associated hardware, including a portable printer to a temporary office. The inspector may need to retrieve fully charged cameras, car adapters, etc. from the MPIU equipment locker. This may be a variety of places such as the stateroom of a vessel or a shipyard temporary office space, usually a space that has a phone-line available. The on-board configuration may reside semi-permanently at a location in a shipyard set aside for Coast Guard Marine Inspector residence.

Several pen-based or pen-convertible based MPIU computers will be located at one of these semi-permanent shipyard Coast Guard inspector offices. The on-board system retains all of the vessel inspections for that site. Records would date back at least a year on the local level. The on-board MPIU will provide the inspectors with electronic access to Category 1, 2, and 3 reference material. The on-board system would be tied into a phone line to access MSN data and to transmit completed vessel inspections. The more portable units will generally remain free for on-site data capture. However, these units will also have the capability to transmit inspection data between MPIU units at different ports or to MSN if needed.

c. MPIU On-Site Computer Configuration

One or more inspectors will use the on-site MPIU units to collect inspection data on the vessel using the electronic inspection booklet applications. The electronic inspection book will have a searching capability to access Category 1 and 2 reference materials. The MPIU on-site configuration will include a digital color camera that can be carried in an inspector's coverall chest pocket.

At the end of the inspection, or daily during a large inspection case, the updated database on the on-site computer(s) is transferred to the on-board office computer. Merging of inspection files of the same vessel are anticipated to take place on the on-board MPIU unit. The inspector uses the on-board MPIU unit to type up any inspection diaries and attach files to the inspection database. These files may include the diary and other text files, drawing and sketch files, and pictures taken with a digital camera. The on-board MPIU unit will be attached to a portable printer. Certificates of inspection, that are allowed to be issued by the local command, will be printed using the on-board configuration. The MPIU computer will configure the certificates to be printed based on inspection data captured on-site. The on-board computer will retain a certificate history file and a minimum record of locally recorded deficiencies for a period of one year.

d. Coast Guard Standard Workstation - Input

Inspection files will be transferred to either the CGSWSIII or directly to MSN from either a on-site portable MPIU unit or more typically from the on-board MPIU computer. The

MPIU program will prepare the inspection files for transfer to MSN. Inspection files will be compressed for transmission and decompressed after transfer to MSN.

3.3 Inputs and Outputs

The minimum database requirements for the MPIU system is addressed in Section 3.4.

The interface between the MPIU and MSN will require careful development to make the communication and transmission of inspection files efficient and generally transparent to the user, since, this is where the greatest productivity gains are to be achieved.

The interface between on-board and on-site MPIU units will allow for the transfer of specific inspection files between field systems. The systems will have the same software. Generally, the MPIU on-board computer will have more memory than the on-site system to retain commonly used inspection files for a group of inspectors operating out of a temporary shipyard office or semi-permanent detachment.

3.4 Data Base/Data Bank Characteristics

a. Inspection Database

This database will contain the following fundamental fields as a minimum. Alternatives may be used to implement the tag and link fields if the same functions are accomplished. Each record in the database will contain these fields. A discussion of the number of records required follows the field descriptions.

Field	**Discussion**
Inspection Type	Corresponds to inspection book titles. A set of individual databases, one for each inspection book, could be retained in the on-board computer or a single database would retain all inspection types that are encountered in a particular inspection detachment.
Part	Corresponds to the part of the inspection book. Some parts are applicable only to U.S. vessels, some to foreign vessels, and some to both. This field is used for the initial sort of records to accurately configure the electronic inspection book by eliminating access to inspection items not required.
Not Applicable Check	On the initial inspection of a vessel, the entire inspection type database would be downloaded to the inspector's MPIU computer and this field would be added. The inspector would check those records that are not applicable for the vessel for deletion from the vessel specific database. At the conclusion of an initial inspection of a vessel, a utility program would be run to delete these records from the file and also delete this field

	from all records, producing a database for use on all future inspections. It is better to use a field like this that the inspector has to check rather than rely on blank records as an indication that they are not applicable.
Major Category	Corresponds to the inspection book categories starting with capital letters, e.g., Emergency Equipment. The field is not essential to the database but could be a useful category for sorting data.
Minor Category	Corresponds to the numbered inspection book categories, e.g., Emergency Lighting. This field is the primary selection field used by the inspector in terms of where data is captured.
Sub Category	Corresponds to bulletized items in the inspection book. Only those sub categories which require data entry need be included. Those without data requirements can be implemented as bulletized text fields in the corresponding computer screen and made to be hypertext linked to the electronic reference library.

The number of records in the inspection database will depend on the type of inspection book involved. Some inspections may require multiple databases. For example, a tankship inspection might also involve a machinery, hull or dry-dock inspection book. Tables 1, 2, and 3 show the number of categories of information from selected versions of the current CG-840 series paper inspection booklets. Figure 6 illustrates how the categories are designated. The electronic inspection book is expected to have at least the same number of categories as the current inspection books and the minimum number of minor and sub category records that are applicable to the inspection being conducted. For example, in Table 1 for tankship inspections, a U.S. tanker carrying hazardous liquids would have records for all minor and sub categories in Parts I, II, and IV. This totals to 302 records.

Figure 6 Example Inspection Book Page

Part _____ **PART I – U.S. TANK VESSELS ONLY**

Major Category _____ **A. LIFESAVING EQUIPMENT**

Lifeboats and Equipment

Minor Category _____ 1. ☐ **Lifeboats and life rafts stripped, cleaned and overhauled.**
Last previous date ***(if other than this inspection)***

Sub Category _____ _____

Minor Category _____ 2. ☐ **Lifeboats and work boats**
- **Hull and fittings**
- **Tanks and fittings**
- **Equipment and stowage**
- **Cradles**
- **Markings**
- **Gripes**
- **Compressed air cylinders**

Minor Category _____ 3. ☐ **Life rafts**
- **Launching instructions posted**
- **Releasing gear**
- **Structure and tanks**
- **Equipment and stowage**
- **Sea painter/cleat**
- **Date serviced** _____
- **Hydro release date** _____
- **Weak link**
- **Float free**
- **Illumination**
- **Markings**
- **Capacities**

Sub Category _____

Sub Category _____

Minor Category _____ 4. ☐ **Life floats**
- **Equipment**
- **Stowage**
- **Markings**

Table 1 Tankship Hull Inspection Book

Tankship Hull Inspection Book								
Part	I		II		III		IV	
Major Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.
A	22	11	16		1	28	6	
B	6	9	7	1	4		3	
C	7	1	5		5		11	6
D	4		1	2	5		8	6
E	5		13		1		5	5
F	2		7	3	3		2	
G	13				3		12	2
H	2				3		5	1
I	5	4			1		6	6
J	8				1		4	2
K	8	2					3	1
L	11	3					6	2
M							3	1
N							3	
O							2	4
P							8	
Q							1	
Total	93	30	49	6	27	28	88	36

Note: Part I is U.S. Tank Vessels Only.
Part II is U.S. and Foreign (As applicable).
Part III is Foreign Tank Vessels Safety Examination Only.
Part IV is Vessels Carrying Hazardous Liquids (U.S. and Foreign).

Table 2 Foreign Vessel and Small Passenger Vessel Inspection Books

Foreign Vessel							Small Pass. Vessel	
Part	SOLAS 60		SOLAS 74		U.S. Reg.			
Major Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.
A	9	5	13	6			3	2
B	3		45				3	
C	45	15	17	4			5	31
D	5	5	10				5	48
E	3	1					7	48
F	5	10					9	20
G	5	1					2	
H					25	2	3	5
I							3	
J							4	1
K							9	5
L							13	3
TOTAL	75	37	85	12	25	2	66	163

SOLAS - United Nations Safety of Life at Sea Conventions

Table 3 Miscellaneous Inspection Books

Inspection Books								
Book	Barge		Hull		Machinery		Drydock	
Major Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.	Minor Cat.	Sub Cat.
A	5	11	22	13	1		22	15
B	7	52	8	10	9	131		
C	2		6	1	1			
D	1		4		2	50		
E	2		7		9			
F	3	3	2		11			
G	4	2	14		7			
H	3		3		1			
I	2	74	5	5	8			
J	3	12	11		7			
K	9		10	2	7	1		
L	11	15	8	2	5	3		
M	31	2	10	2				
N	12	6						
TOTAL	95	177	110	35	68	185	22	15

b. Deficiency Database

A field level database will be used for tracking deficiencies recorded or captured using the MPIU system. The inspector will be able to customize reports on all of the inspection data available either in an on-site or on-board unit. The deficiency database can be sorted to perform a sorting of deficiencies on a single vessel or all of the vessel inspections available on the computer. Additional sorting capabilities include viewing open deficiencies and worklists on all class of vessels or a specific vessel.

c. Reference and Regulatory Database

Three categories of reference and regulatory materials, based on frequency of need, are apparent from the analysis of the survey performed in Phase 1 and 3 studies. The three categories are ranked in terms of need in the field.

Category 1 includes:

- Title 46, Code of Federal Regulations (CFR), Subchapters D, F, H, I, J, T

Category 2 includes:

- Parts of Title 46, CFR, other than those in Category 1
- Parts of Title 33, CFR
- Title 49, CFR
- USCG Navigation and Vessel Inspection Circulars (NVICs)
- United Nations Safety of Life at Sea Conventions (SOLAS)
- American Bureau of Shipping Rules for Building and Classing Steel Vessels
- USCG Marine Safety Manual (MSM), Vol. II
- USCG Marine Vessel Inspection (MVI) Policy Letters
- Local Officer in Charge of Marine Inspection (OCMI) Policy and Inspection Guidance Memos
- International Maritime Organization (IMO) Mobile Offshore Drilling Unit (MODU) Code
- MARPOL
- Alternate Compliance Program Supplement
- International Convention on Standards of Training Certification and Watch Keeping

Category 3 includes:

- IMO Gas and Chemical Tanker Codes
- USCG MSM Vols. III and IV
- IEEE Shipboard Electrical Code
- American Boat and Yacht Council (ABYC) Standards and Recommended Practices
- National Fire Protection Association (NFPA) Codes and Publications

- ANSI/NFPA National Electrical Code (NEC)
- Selected American Society for Testing and Materials (ASTM) Specifications
- Other ABS Rules

Tables 4, 5, and 6 quantify the storage requirements for the textural and graphical content of the documents in Categories 1, 2, and 3, respectively. The total estimated memory required to store Category 1 references, with graphical drawings which are incorporated into the text, is 8 Mbytes. This is based on one page of test requiring 3 Kbytes of storage, and a small graphical drawing, with incorporated text, requiring 50 Kbytes of storage. The total storage space required to contain all three categories of reference materials is 200 Mbytes which is a conservative approximation.

Table 4 Category 1 Reference Materials

Text	Pgs	Kbytes (pgs*3K)	pgs of graphics	Kbytes (graphics*100K)	Kbytes (total)
Tank Vessels	170	510	5	500	1000
Marine Engineering	230	690	25	2500	3200
Passenger Vessels	170	510	5	500	1000
Cargo & Misc. Vessels	160	480	5	500	1000
Electrical Engineering	70	210	5	500	700
Small Passenger Vessels	90	270	5	500	800
Total	890	2670	50	5000	7700

Table 5 Category 2 Reference Materials

Text	pgs	Kbytes	pgs of graphics	Kbytes (graphics *100K)	Kbytes (total)
Title 46 Code of Federal Regulations					
Procedures Applicable to the Public	70	210	5	500	710
Merchant Marine Officers and Seamen	120	360	5	500	860
Uninspected Vessels	20	60	5	500	560
Load Lines	90	270	5	500	770
Documentation and Measurement of Vessels	40	120	5	500	620
Mobile Offshore Drilling Units	60	180	5	500	680
Dangerous Cargoes	10	30	5	500	530
Certain Bulk Dangerous Cargoes	250	750	5	500	1,250
Equip., Const., & Material Specs and Approval	400	1,200	10	1,000	2,200
Nautical Schools	40	120	5	500	620
Subdivision and Stability	90	270	5	500	770
Ocean Research Vessels	100	300	5	500	800
Marine Occupational Safety and Health Standards	20	60	5	500	560
Title 33 Code of Federal Regulations					
Waivers of Nav. and Vessel Inspection Laws...	10	30	5	500	530
Navigation Rules	40	120	5	500	620
North Atlantic Passenger Routes	10	30	5	500	530
OCS Activities	30	90	5	500	590
Pollution	150	450	5	500	950
Port and Waterway Safety	130	390	5	500	890
Title 49 Code of Federal Regulations	1500	4,500	25	2,500	7,000
Title 33 Code of Federal Regulations (other parts)	2000	6,000	5	500	6,500
USCG NVICs:					
26 NVICs most commonly cited	1400	4,200	75	7,500	11,700
SOLAS Publications (48,60, 74, 83)	550	1,650	5	500	2,150
American Bureau of Shipping Rules:					
Rules for Building & Classing Steel Vessels	5280	15,837	140	13,900	29,737
USCG Marine Safety Manual Vol. II	400	1,200	5	500	1,700
USCG MVI Policy Letters	300	900	0	0	900
Local OCMI Policy Instructions (est.)	150	450	0	0	450
IMO Codes:					
Code for the Const. & Equip. of MODU	100	300	10	1,000	1,300
Alternate Compliance Program Supplement	50	150	0	0	150
Intl. Convention on Standards of Training Certification and Watch Keeping	200	600	0	0	600
MARPOL	200	600	0	0	600
Total	13760	41280	365	36,500	77,827

Table 6 Category 3 Reference Materials

Text	pgs	Kbytes	pgs of graphics	Kbytes (graphics *100K)	Kbytes (tot.)
Marine Safety Manual Volume III	130	390	5	500	890
Marine Safety Manual Volume IV	250	750	5	500	1,250
NFPA Codes and Publications	200	600	20	2,000	2,600
ASTM Specifications	230	690	25	2,500	3,190
National Electrical Code	1075	3,225	50	5,000	8,225
ABYC Standards	400	1,200	100	10,000	11,200
IEEE Code	180	540	10	1,000	1,540
USCG NVICs:					
127 NVICs less commonly cited	1,905	5,715	200	20,000	25,715
American Bureau of Shipping Rules:					
Guide for R, W, Cladding... of Tail Shafts	20	60	5	500	560
Rules for Building & Classing Aluminum Vessels	125	375	5	500	875
Rules for B&C Mobile Offshore Drilling Units	75	225	5	500	725
Rules for B&C Reinforced Plastic Vessels	75	225	5	500	725
Rules for B&C Steels Vessels Under 61 Meters	70	210	5	500	710
Total	4,735	14,205	440	44,000	58,205

3.5 Failure Contingencies

a. Backup

The on-site MPIU unit should be backed up to the on-board computer once a week. Inspections should be backed up to a disk on completion and retained by the inspector until MSN validation occurs. The on-board computer will have some form of external storage such as a backpack external hard drive or zip drive that will back up the on-board computer once a month. The external harddrive will also serve to update inspection detachments with extensive regulation references that require large memory by physically off loading data from MSN at the MSO/ MIO CGSWSIII.

b. Fallback

The fallback position for an on-site computer is to use a spare on-site computer or on-board MPIU system. Similarly, the backup for the on-board MPIU unit is to use one of the on-site systems to communicate with MSN, handle certificate printing, and deficiency queries at the on-board location.

c. Degraded Modes of Operation

Inspection data can continue to be captured electronically if the inspection data collection portion of the MPIU system is functional even if access or queries of the reference library, digital photographs, or drawing templates are not possible.

4 Design Considerations

a. Standard Workstation Hardware

CGSWSIII hardware is assumed to be a PC DOS-based system with RS-232 and/or parallel communication ports for direct CGSWSIII to MPIU communications and a fax/modem for transferring files and communicating with MPIU units in the field.

b. MPIU On-Board Configuration Hardware

The on-board MPIU system is expected to be used in a protected environment such as a temporary office space in a shipyard.

The following physical requirements given below are to be met.

MPIU On-Board Physical Requirements

Maximum Size	12"W x 10"D x 2"H
Minimum Active Display Size	8.5" diagonal
Minimum Display Resolution	SVGA 640 x 480 pixels
Minimum Weight	10 lbs including batteries
Shock Resistance	Must withstand rough handling associated with airplane travel, while closed or while inside a carrying case.
Moisture Resistance	Withstand exposure, while operating, to the high humidities often found near ships.
Temperature Resistance	Computer must operate in ambient temperature range from 60^0F to 90^0F. Computer must withstand temperatures of -20^0F to 170^0F for 8 hour periods while not operating, without loss of information in non-volatile memory or any permanent physical or electronic damage.
Resistance to EMI	Resistant to data loss and permanent or temporary circuit damage due to interference from operating shipboard equipment such as generators, alternators, motor-generator sets, switchboards, and electronic navigation equipment, in close proximity. While being shipped, the computer must be resistant to circuit damage or loss of data in non-volatile memory due to x-ray emissions from airport security systems.
Environmental Factors	The computer, screen, and any exposed connectors must

	be resistant to damage from dusts commonly encountered in the shipyard environment or aboard bulk carriers, such as sandblasting grit, wheat and other grains, and ores and various metals.
Memory	Nonvolatile memory: conventional internal hard disk Minimum nonvolatile memory: 300 MB Preferred nonvolatile memory: 1 GB Minimum RAM capacity: 16 MB w/ user upgrades to 32 MB
Processing Capabilities	Maximum text screen rewrite: 1.5 sec Maximum graphics screen rewrite: 2.5 sec Minimum data transfer rate: 19200 baud
Batteries	Rechargeable batteries with easily replaceable battery pack giving at least 3 hrs operating time with the display on. Operable from a standard AC power supply. Provided with one spare set of rechargeable batteries.
Power Supply	The computer must have an adaptable power supply for 110/120/220/240 VAC 50/60 Hz power, with a power cord and international power supply plug adapters.
Assessories	Equipped with a 101-key enhanced keyboard. Outer hard shell case with padded lining with handle and shoulder strap, latches, and a lock which can travel as carry-on baggage on commercial aircraft. Computer in case will float if dropped. Battery charger to charge one set of batteries in 1 hr. Mouse or trackball and pen stylus. Cigarette car adapters. I/O ports include a minimum of one RS-232 and one Centronix compatible port. Cable to connect MPIU on-site pen computer to MPIU on-board computer. Internal 19200 fax/modem or PCMCIA compatible fax/modem which would require the computer to have a minimum of Type II PCMCIA slots. Internal 3.5" 1.44 MB Extra High-Density floppy disk drive. Parallel printer adapter and connector for portable printer. Lightweight portable laserjet quality printer which can

print color graphics to plain 8-1/2" x 11" cut sheets in landscape or portrait orientation.
Carrying case compartment storage for extra printer ink cartridges, floppy disks, and paper.
External portable harddrive in either a backpack or zip drive fashion.

c. MPIU On-Site Configuration Hardware

The size of the portable MPIU unit directly impacts its functionality; thus size and weight are considered to be performance related factors. The size limits are established by the minimum allowable display size and the maximum allowable overall size. The pen-based computer will function as a portable computer or an on-board computer, e.g., notebook when attached to a docking station or full-sized keyboard.

The on-site unit will be designed for pen-based computing and will have a backlit display visible in a dark room, bright sunlight, and all lighting conditions in between. The microprocessor used shall have adequate speed and capacity to be used as a CAD processor.

The on-site unit will be provided with a cushioned external case to provide buoyancy and shock resistance. The external case will remain on while the computer is in use and not interfere with the use of any computer controls or communication ports.

The on-site unit must be battery operated for a period of 6 hours before recharging. External communication ports will be provided to allow for communications with the on-board computer.

MPIU On-Site Physical Requirements

Maximum Size	9"W x 9"D x 1.5" thick
Pen	Requires a non-electronic, pen-shaped pointing device which is required to be securely attachable and easily removable to and from the computer.
Display	The pen-based computer will support an external monitor with the same resolution and the integral display - the pen-based computer will require an internal color and externally support standard color monitors - the pen-based computer will simultaneously drive the external monitor and integral display. The integral display will have the following minimum requirements: 640 by 480 pixel color resolution.

	An active area that measures 6 inches diagonally. Unlighted readable that provides a minimum of 3 to 1 contrast ratio in all illumination conditions including direct sunlight and dark ambient lighting conditions with backlight at middle luminance at least 35 candles/m^2 and at viewing angles of +/- 20 degrees horizontally and vertically - the contrast ratio is equal to the ratio between the brightest shade of gray compared to the darkest shade of gray. Individual operator-adjustable brightness and contrast controls. Backlight or sidelight display with no flicker.
Maximum Weight	5 lbs including batteries.
Shock Resistance	Desirable to withstand occasional drops from 4 feet onto a hard flat surface without the soft external case while operating (this requires approximately 300 g's shock resistance). Deisirable to withstand repeated drops from 8 feet onto a hard flat surface while in the external case while operating. The ability to withstand a terminal-velocity drop onto a hard flat surface while in the protective case is desirable but may not be possible.
Buoyancy	Must float in liquids having a specific gravity of 0.8 (similar to kerosene) when in or out of the external protective case.
Chemical Resistance	Withstand crude oil frequently smeared on the case and screen.
Moisture Resistance	Withstand exposure, while operating, to salt water spray and short term submergence in salt water to a depth of 1 foot for 30 seconds, without immediate or long term damage which would affect operating capability. Capable of being washed off frequently with a low-pressure fresh water hose without damage. The display must withstand frequent cleaning with water and soap to remove oil and dust residues without significant degradation of usability or visibility.
Temperature Resistance	Computer must operate in ambient temperature range from 0^0F to 140^0F.

	Computer must withstand temperatures of -20^{0}F to 170^{0}F for 8 hour periods, while not operating, without loss of information in non-volatile memory or any permanent physical or electronic damage.
Resistance to EMI	Resistant to data loss and permanent or temporary circuit damage due to interference from operating shipboard equipment such as generators, alternators, motor-generator sets, switchboards, and electronic navigation equipment, in close proximity. While operating, the device must be resistant to data loss or damage due to interference from on-board or shipyard operations such as welding and NDT x-rays. While being shipped, the computer must be resistant to circuit damage or loss of data in non-volatile memory due to x-ray emissions from airport security systems.
Environmental Factors	The computer, screen, and any exposed connectors must be resistant to damage from dusts commonly encountered in the shipyard environment or aboard bulk carriers, such as sandblasting grit, wheat and other grains, and ores and various metals.
Memory	Nonvolatile memory: conventional internal hard disk Minimum nonvolatile memory: 200 MB (with options to upgrade memory) Preferred nonvolatile memory: 1 GB Minimum RAM capacity: 16 MB w/ upgrades up to 32 MB The computer shall have two Type II or greater PCMCIA compatible slots - the slots will support hot replacement of PCMCIA cards.
Processing Capabilities	Maximum text screen rewrite: 1.5 sec Maximum graphics screen rewrite: 2.5 sec Minimum data transfer rate: 19200 baud
Batteries	Rechargeable batteries with easily replaceable battery pack giving at least 6 hrs operating time with the display on. Operable from a standard AC power supply. Provided with one spare set of rechargeable batteries.
Power	The pen-based computer will include an AC adapter with

surge protection with adequate power to support the pen based computer and all peripherals such as PCMCIA cards and charge the battery while in use.
Included will be an internal, user replaceable, battery capable of providing a minimum of 6 hours of continuous use with power management and the batteries will not develop a usage memory that affects available charge capacity.
An optional separate and orderable DC power for the pen-based computer is required and use 12 volt and 24 volt power sources and provide adequate power to support the pen-based computer and all peripherals and charge the battery while in use where the DC supply will be capable of being used in a cigarette lighter plug.
An orderable battery conditioner will be available which will completely discharge and trickle charge the battery and will provide a rapid charge that charges the battery in less than 3 hours.

Intrinsic Safety

The unit must be modifiable so that it becomes intrinsically safe while retaining all of its capabilities (an undefined cost is associated with this) where the modification may be done to a number of systems in cases where use of the MPIU is desired in a potentially explosive environment and where intrinsically safe MPIU systems will be assembled on a case by case basis.

Assessories

Cable to connect MPIU on-site pen computer to MPIU on-board computer.
A full-size detachable keyboard is required.
A PCMCIA compatible fax/modem with software which provides at least 19200 baud.
I/O ports include a minimum of one RS-232 and one Centronix compatible port.
External 3.5" 1.44 MB Extra High-Density floppy disk drive.
Lightweight inkjet B&W printer which can print graphics to plain 8-1/2" x 11" cut sheets in landscape or portrait orientation.
Color digital camera with communication cable and spare rechargeable batteries - nonvolatile memory for a min. of 32 frames, millions of colors, built-in on the spot viewer such as a small LCD display, and close-up capability to at least 1 foot from the picture object.

4.2 System Functions

System functions are described in sections 3.1 and 3.2.

4. 3 Flexibility

Flexibility has been assured by specifying off-the-shelf hardware and software wherever possible. Certain capabilities of the system, such as memory, are likely to increase rapidly. It is anticipated that all reference materials including new additions to the database can be stored on the nonvolatile system memory.

Flexibility can be enhanced by choosing operating systems and/or applications for the on-board and on-site computers which are industry standards. Operating systems proprietary to one company should be avoided.

4.4 System Data

System data has been described in Section 3.4. The size of the inspection database was estimated based on a combination of requirements for the U.S. tank vessel carrying hazardous liquids together with the machinery, hull, and dry-dock inspection books.

5 ENVIRONMENT

5.1 Equipment Environment

ADP equipment that is presently available in the Coast Guard infrastructure is comprised of BTOS/CTOS based Standard Workstation platforms. There are presently no means of uploading ASCII data that would reflect MPIU inspection files into the existing MSIS. There exist procedures for the downloading and uploading of files between the Coast Guard BTOS/CTOS CGSWSII and MSDOS platforms. There are a few costly commercially available products that would permit running a BTOS/CTOS application from a MSDOS platform.

This system is being phased out and replaced with the CGSWIII. The CGSWIII will be MSDOS based PC systems and represents the Coast Guards microcomputer architecture throughout the year 2000. The 486 desktop units and portables will support the Windows NT operating system. The CGSWIII notebook portables will consist of Pentium 75Mhz with 800MB and 16MB of RAM and a docking station with CD-ROM drive. This computer will meet the needs of the on-board configuration.

5.2 Support Software Environment

The CGSWIII will have Word and Excel as the standard word processing and spreadsheet tools. The MPIU applications are expected to reside with the CGSWIII word processing

routines so that inspector can take advantage of sophisticated word processing features for his or her smooth diaries.

5.3 Communications Requirement

Communications are required between MPIU field units and between MSN and MPIU units. The communications interface must be capable of transferring and receiving data between the PC based systems via direct parallel ports and modem serial communications. Compression and decompression routines will be utilized to handle large inspection files which may include digital pictures and graphics. These routines will be transparent to the users.

5.4 Interfaces

MPIU to MPIU Interface
An interface is required between MPIU on-board and on-site units with optional communications of direct connection, modem, and disk exchanges. A minimum level of tracking of a successful file transfer will include a minimum of a return receipt.

MPIU to MSN Interface
On initiating an inspection, MSN will provide the case history and pre-inspection data with an appropriate case and vessel identification number to the MPIU unit. This will be done over a phone line, direct connection, or through disk exchange. After completion of an inspection case the MPIU program will perform the necessary coding of inspection data before transmission to MSN. MSN will read the MPIU file and import this data into appropriate database fields.

5.5 Summary of Impacts

The implementation of a portable computerized inspection capability will eliminate the need of clerical staff presently responsible for transcribing and coding inspectors field notes into a form transmittable to MSIS.

A limited reduction in the number of marine inspectors assigned to each MSO/MIO will be possible.

The timeliness of inspection data available on the new MSN will be improved.

Additional responsibilities will be assigned to the MSO/MIO unit systems manager.

5.6 Failure Contingencies

All failure contingencies are discussed in Section 3.5.

6 SECURITY OF DATA

6.1 Background Information

It is assumed that MSN mainframe will have security measures to control the dissemination of sensitive inspection information.

6.2 Control Points, Vulnerabilities, and Safeguards

Input Control Points
Inspection data collection will initiate in the field with the on-site MPIU. Additional inspection data may be prepared and entered in the on-board MPIU configuration back in the temporary office.

Process Control Points
Initial inspection data will be retrieved from MSN via modem, direct connection, or disk to the MPIU units.

Inspection data may be passed between the on-site MPIU unit, other on-site MPIU units employed in the same vessel inspection, or MPIU on-board MPIU unit to view related inspections (past or present) in the local database.

Inspection data may be exchanged between on-board MPIU units from different ports or shipyards, e.g., where a previous inspection took place on that vessel.

Completed inspection files will be transmitted from the MPIU field units to the MSN.

Output Control Points
MSN will receive completed inspection files generated on the MPIU units. MPIU units at other ports or shipyards are authorized to receive completed vessel inspections provided the disposition of the validation status is known.

Vulnerabilities
The marine inspector is responsible for the MPIU he or she takes on a vessel. The inspector may set the unit down to access a confined area of the vessel.

Inspection data may be passed between MPIU units over an unsecured phone line.

Inspection data will be passed between MPIU units and the MSN over an unsecured phone line.

Safeguards
In the case of the marine inspector who must temporarily leave the MPIU unit behind to access a particularly confined space, he or she will physically lock the computer to a structure using a steel cable to prevent theft of the MPIU unit or alternatively leave the MPIU unit in a reasonable secure area of the vessel.

Each MPIU unit will employ its built in boot password protection so that no one can operate the computer without first typing the password. Most computers also offer password protection for the setup program. In this case access can be denied to the Setup where changes to the MPIU system configurations are made.

The exchange of inspection information between MPIUs over phone lines will be initiated by inspectors by physically calling the operator of the remote MPIU unit. Therefore, MPIU units will not remain on phone lines any longer than required to transmit/receive inspection files.

The exchange of information between an on-board MPIU unit, which may also be a CGSWSIII notebook, set up as a client/server to MSN will require the same safeguards as placed on the MSN mainframe. A client/server must minimize a multivendor environment so that the same security applications can be applied.
the speed of the MPIU program to determine if an appropriate key is attached.

6.3 System Monitoring and Auditing

The MPIU will have the automated feature of tracking the receipt and transmission of inspection data between units in the same office or between different inspection offices. At a very minimum an electronic return receipt will be associated with the successful transmission of an inspection file. A better system would involve the specific vessel inspection retaining a journal history of all transfer transactions and would include a minimum of the following tracking information:

vessel name
date of inspection data exchanged
MPIU unit No. of transmitting unit
MPIU unit No. of receiving unit

7 SYSTEM DEVELOPMENT PLAN

It is recommended that a pilot program be initiated at a Marine Safety Office or Marine Inspection Office. This pilot program would involve the use of sufficient hardware and software needed to equip the entire portion of the inspection office responsible for field inspection activities. It is essential to have a pilot program before full-scale implementation takes place. Several competing products should be tested to determine the best features for the Coast Guard MPIU. This includes competing pen-based computer operating systems and hardened portable systems that claim virtual indestructibility in field use. The pilot program should be limited to two years so that a practical and fully functional MPIU system is implemented Coast Guard wide with the new MSN.

During the pilot program, refinements can be made to the functional description for a full scale buy of hardware and software. The timing of full-scale implementation will be

dependent on the parallel development of MSN. However, much improvement is possible with the field MPIU system in terms of improved functional requirements, improved software, and effective interfacing requirements, even if a crude computer MPIU-MSN interface is employed.